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General Sir WILLIAM J. CODRINGTON, G.C.B., &c., &c., Vice-President, in the Chair.

"MY TRAVELS IN MESOPOTAMIA, ESPECIALLY WITH "REFERENCE TO A PROPOSED INDO-MEDITERRANEAN "RAILWAY."

By Commander V. Lovett Cameron, C.B., D.C.L., R.N.

The subject to which we have to turn our attention to-day is one of vast importance to this country, and since the days of General Chesney has never been lost sight of by some among us, although the startling occurrences of modern history have often caused the general ideas of the English nation to be turned in other directions.

The subject of railway communication between the Mediterranean and Persian Gulf has already been discussed here, and it is with feelings of diffidence that I now venture to give my opinions on the subject, knowing that every authority hitherto has differed as to the line to be followed, and that I myself agree with no one as to the precise route, though I do in the main idea that it is of the utmost importance to us as a country strategically, commercially, and politically to connect the Persian Gulf and the Mediterranean Sea, by a line of railway which ultimately may be prolonged so as to join our Indian railway system.

I will now describe the country I travelled over, having a special reference to railway construction.

From Cyprus I went by steamer to Beirut, and then when we had collected our baggage animals, we crossed the Lebanon into Cœle Syria, by the French road between Damascus and Beirut. Turning northwards at Shtaura, we went up the valley between the Lebanon and Anti-Lebanon to Homs. At Homs we were assured that the best pass between the sea coast and the fertile plains of the interior lay between it and Tripoli. I had, before this, the intention of going to the sea coast near the mouth of the Nahr el Kebir, and northwards along the coast to Latakia, in order to look for a practicable pass in the mountains; this news determined me to go to Tripoli, and thence, if it proved correct, work back again to Homs.

A Zaptieh was given us as guide, who was said to know the best way, but who took us the shortest way and the one now followed by many of the caravans; this road, however, did not seem very promising, as the plains which fringed the sea were separated from the plateau we had been crossing by an almost precipitous descent, down which wound a narrow slippery zigzag path. But when we arrived at Tripoli, we were told by our Vice-Consul, Monsieur Blanche, who has spent many years there, and is well acquainted with the topography of the surrounding country, that we had been brought the shortest line, but not the best, as by going round a little way and following the line of the old Roman road, we should find an easy route from the coast plains into the interior.

Tripoli is now a place of less importance than either Beirut or Iskanderun, but her position at the mouth of the most practicable pass into the interior ensures for her a most important future. She was in ancient times a larger and richer town than any of her modern rivals, whilst her predecessor, Arvad of the Phœnicians, now the desert Island of Ruad, was a competitor with Tyre.

During all times but the most modern, the route which we took from Tripoli back to Homs was the most important of all those between the coastline and the interior. The Egyptians in their wars against the Hittites made use of it, and the foundations of Kalaat Ibn Hosn, a fortress which has played a part in many a forgotten war and campaign, show traces of their handiwork. As the Egyptians invaded the Hittites before the days of Moses, this position has long been regarded as one of importance. The two wadys by which the higher level is reached join together very curiously in the centre of their length; and whilst below this junction one is too narrow and has its sides too precipitous to be of use for carrying a road up it, above this point it is wide and easily ascended, whilst precisely the reverse is the case with the other.

The Romans, in forming their road into the interior, took advantage of this peculiarity, and in many places their ancient causeway might be utilized in the construction of a railroad, although of course in some cases the gradients would be too steep. From the watershed (highest point 1,100 feet) at the head of these wadys a gentle slope leads to the fertile plain of the Lesser Bukéa (level 720 feet); this crossed, a second line of hills has to be crossed, but for only about 3 miles did any difficulty present itself, and that might be easily overcome. In crossing this plain, 180 feet was risen almost imperceptibly, and then for the first 3 miles to Hadeedy, 300 feet more would have to be ascended, or a gradient of 1 in 60. From Hadeedy 350 feet more would have to be risen to arrive at the highest point between Homs and the sea. Here the steepest gradient would not be above 1 in 80. Some old Roman bridges show that once there were rivers running on this piece towards the Lake of Homs, and some provision would have to be made for the flood waters, and at one place near Jisr Achan (Bridge of Achan) it might be better to cross a small valley by an embankment and cutting instead of making a *détour* to avoid it, or by using

heavy gradients. From the highest point a very easy slope brings the line down to the Orontes, which here can be easily crossed, and the town of Homs is at once reached. Homs is even now a place of considerable importance, and is well situated as being a point whence level roads diverge towards Damascus, Baalbec, and Hamath.

Homs is also on the direct route to Palmyra if at any time the Palmyrene Railway should be decided upon, and, therefore, is destined to be one day a great junction station.

Any body of troops concentrated at or near Homs, and having railway communication with Tripoli, would command the whole of Syria behind the ranges of the Lebanon; grain, cattle, and sheep are abundant, and in addition to the water supplied by the Orontes and its affluents, wells of no great depth (about 30 or 40 feet) might be easily made where required.

If ever the Suez Canal is to be threatened by an army marching from Asiatic Turkey, that army would have to pass through the districts around Homs, and a force there might easily be reinforced from Cyprus if the railway to the coast be constructed.

There are the remains of large barracks which were constructed by the Egyptians during their occupancy of the country, and although now destitute of doors and windows, and looking in a ruinous and dilapidated condition, still they were so well built originally that they might easily be put in repair.

The whole country is so flat that there would be no difficulty in moving troops in any direction, and if wheeled vehicles were imported, there is nothing to prevent their being used. Mules, camels, and horses are plentiful, and if the friendship of the Aneyzeh Arabs were secured, an almost unlimited number of camels might be procured at a very cheap rate.

From Homs to Hamath, with the exception of crossing the valley of the Orontes, at Rusta, there is scarcely any work to be done, and the whole country is fertile, and, under a settled and just Government, the population, at present huddled together miserably in the towns, could be profitably employed in agriculture.

The Orontes at Rusta runs in the bottom of a gully about 120 feet below the general level of the plain; here was once, as at all other important points, a Roman fortress which defended the passage of the river. The southern side of this gully widens out and slopes gradually just to the west of the village, and an easy gradient would bring us down the first 60 feet from whence a viaduct of about 300 yards in length would take us to the north of the river. Here the line might either wind round the curve of the bluff, or a cutting 60 feet deep at the commencement, running down to nothing at the end, be made for a distance of half a mile.

After this, as far as Hamath, the line might be laid on the surface, only levelling, ballasting, and drainage having to be attended to.

At Hamath, the Orontes would have to be crossed again for the third and last time, but as its valley widens out around the town, no difficulty would be met with here beyond that of bridging the stream.

Hamath is one of the most ancient towns now existing in the world, and is constantly mentioned in the Pentateuch and other historical portions of the Bible. When we were there, it was crowded with Circassians who had been deported from European Turkey, and who here, as elsewhere, were a very great source of trouble to the authorities. Here also, as at Homs, are old barracks which might be repaired, and the khans or caravanserais might also be used for the accommodation of troops. The Aneyzeh have more dealings with the Governor (Mutesarif) of Hamath than they have with the Kaimacan at Homs, and perhaps, therefore, this might be a better spot to collect camels from them. The land which is irrigated by the Orontes is most fertile, and if modern systems of raising and distributing the water were used instead of the cumbrous and clumsy wooden wheels and antiquated aqueducts, it might be enormously increased in extent and productiveness.

At Hamath, the valley of the Orontes is gradually left, and the whole distance thence to Khan Shaykh Khaun is almost perfectly level, the only works necessary being bridges over three river beds, which in the rainy season carry the flood-water from the higher land on the east, down to the Orontes.

The khan here is an old building, at all events dating from the days of the Crusaders, and would afford shelter to a large body of men and stores, and would be perfectly defensible against everything except artillery, and the outer walls are so thick and solid that it would require a long-continued fire from the heaviest field guns to breach them. Water is here obtained from wells and is not very good; if the wells were bored deeper the supply would be more abundant and most probably purer. An old stone-lined tank lies outside the south-east corner of the khan, but it has been neglected and is now useless; doubtless it might easily be repaired, and if care were taken, every year's rains would fill it and afford a supply for the months of drought.

At Khan Shaykh Khaun, the hills which form the edge of another plateau are reached, and an easy ascent leads to their summit. An average gradient of 1 in 120 would, by following the curves of the hills, bring the line to the highest point between Khan Shaykh Khaun and Marah. Marah, which lies in a slight valley, may be reached by a gradient averaging 1 in 250, and thence again the level of the plateau may be equally easily reached. Though anciently all this country was covered with large and wealthy towns, it is now quite bare and deserted. Immediately round Marah are vineyards, and wheat is cultivated, but the people live in dread of the Bedouins, and dare not go far afield. The khan here is even larger than that at Shaykh Khaun and was repaired by Ibrahim Pasha. It might easily be converted into very good barracks, and there are the ruins of an old Genoese castle which might also be utilized. The town itself is mean and miserable, though if the Kaimacan was to be believed it was very prosperous and exported large quantities of grain and raisins.

Some idea of the want of order that exists about here may be drawn

from the fact that some Bedouins made a dash right into the khan, and drove off some mules, though their owners outnumbered them by more than two to one, and even when the Zaptieh were appealed to, they refused to follow the raiders.

From Marah a slight rise brings one again on to the higher level, which if it were not for the purpose of collecting the traffic of the town and district, need not have been quitted; thence to close to Aleppo, the whole road is practically a level one. Around Marah are an enormous number of ruins, dating from the latter days of the Byzantine Empire: these show that once the whole of this country was densely populated; and as we went along we saw several small towns and villages besides the important one of Idlib, and numerous villages. The smaller towns and the villages are now, or were when we passed by, greatly troubled by the Arabs. Some years ago the Arabs of the desert used to levy blackmail from their inhabitants, who are also Arabs, and in return used to prevent the Turkish tax-gatherers from collecting the taxes. The then Wali of Aleppo, in order to meet this difficulty, organized a corps of rifles, mounted on mules, who were able to keep the Bedouins in check, and the peasantry paid taxes to the Turks instead of blackmail to the Aneyzeh. The needs of the Porte during the Russo-Turkish war led to this corps being sent as infantry to join the army in the field, and now the Aneyzeh have extorted blackmail, and what they are pleased to consider the arrears, and also allow the taxes to be collected, the peasantry, therefore, are in greater straits than ever they were. At Khan Tomaun, near Aleppo, the caravan road from the south leads over some stony hills, but by following the valley of the River Halep, an easy and level road may be found.

Aleppo in ancient days was the principal emporium of Eastern commerce, and at present it is calculated that 80,000 camels are employed in her carrying trade, 10,000 of which are to be found between Aleppo and Iskanderun.

The barracks built by Ibrahim Pasha are capable of holding 10,000 troops, and there is a very fair military hospital which, at the time of my visit, was occupied by deported Circassians. The khans, which are numerous and spacious, would also lodge large numbers of men, and there are many large houses belonging to merchants and private individuals, as well as arcaded bazaars, which might all be utilized in the case of necessity. The citadel is in a very ruinous condition, but a great portion might be roughly repaired and rendered of use.

Owing to the commercial importance of Aleppo, and the number of pack animals constantly passing through, transport and supplies for a very considerable body of men might easily be collected there, and as it commands the routes to Syria, Iskanderun, Aintab, and those of the Euphrates Valley and Mosul, it will always be a place of the greatest strategical value.

If the line were commenced, as most people consider it should be, at Seleucia or Iskanderun, very much greater engineering difficulties would have to be encountered than by the route I have traced out, the fertile regions around Homs, Hamath, and Idlib would be left unprovided for,

and if an army from the north or east had managed to possess itself of Aleppo, there would be no means of opposing its advance on the Suez Canal, through Syria and Palestine, whereas, even if Aleppo should be in an enemy's hands, we could by the line I advocate pour in troops and supplies from Tripoli on Homs, and there make a second stand to cover our great waterway to the East.

Proceeding eastwards from Aleppo as far as Tedif, a small town, four miles from Bab, where there are barracks, which might be made to contain 2,000 men, the ground is quite level, and then some gentle undulations would have to be crossed before arriving at Hierapolis (Mombedj). Here are settled some Arabs, who claim to belong to the great Aneyzeh tribe, and who are especially friendly to the English, as are all the inhabitants of the surrounding country, except some of the deported Circassians, who are enemies to every one, including themselves. These Arabs would be of use in constructing a railway, and from them and their relations in the desert might be gathered a number of hardy horsemen, who, with a little training and teaching, might render invaluable service in war-time as scouts and also for harassing the convoys of an enemy.

From Mombedj the most level line to the Euphrates would be to the embouchure of the Nahr Sadshur, where a bridge might be easily constructed at a camel ford; the Romans indeed bridged the river a little lower down and where the water is deeper, and I can conceive no difficulty to a modern engineer in constructing a bridge across a river where the greatest depth of water would be four feet, and where the foundations of many of the piers might be made on islands and shoals which are dry for the greater portion of the year.

When the river is crossed, some insignificant hills have to be passed through, and then the plain, level as a billiard table, on which are situated Haran and Urfa, is reached. Haran is now only inhabited by a few sedentary Arabs, but there are the remains of the Roman camps and also of the castle, church, and fortifications built by the Crusaders under Baldwin and his successors, Counts of Urfa.

Urfa itself is a place by which a good deal of trade passes, being situated at the foot of the hills over which the road to Aleppo viâ Bir-ed-jik runs, and most of the traffic between Aleppo and Mosul and Diarbekr passes by. Monsieur Martin, the French Vice-Consul, who owns a considerable amount of land in the neighbourhood, and also buys grain in large quantities, told me he often despatched over 600 camels to the coast, loaded with wheat, in one day, and sometimes had sent off 1,200 in one caravan.

There are some very good barracks in good repair, which would hold three or four battalions of infantry, and the khans and the Government buildings at the Serai might also be utilized. The old walls round the town are in many places in fair condition, and on the sides towards the plain there is a deep ditch, almost a ravine. The place might easily be made defensible against troops unprovided with siege artillery.

Crossing the plain from Urfa, and keeping under the mountains

which form the boundary between the Northern Mesopotamian Plain and the high lands of Armenia and Kurdistan, we should for a short distance have to pass through low and rounded hills, where some slight works might be necessary; but once these hills are passed, an unbroken plain extends away to the east of Nisibin.

At the southern end of the Karaja Dagh there is a break in the line of mountains, and an easy road, or a branch line, might be made to the important city of Diarbekr.

Diarbekr is still enclosed within walls, of what date it is difficult to say, but the curious way in which carved and sculptured stones of different periods are placed in juxtaposition tells something of the many vicissitudes through which the city has passed.

Of old the capital of Armenia, it even now is one of the most important points in these regions. When the railway through Anatolia from the Bosphorus is constructed, Diarbekr is sure to be one of the places through which it will pass. It commands the passages of the Tigris, and an army corps having its head-quarters at Diarbekr ought to command the upper waters of both the Tigris and Euphrates, and be able to prevent an army advancing from Kars and Erzeroum, either on Syria or Baghbad, from utilizing these rivers for the purposes of transport. Diarbekr is even of more account in the present day because of her bridge than because of her walls and ancient churches and mosques. The same story may be read in the stones of the bridge as in those of the walls, and its earliest parts most probably date from before the Christian era.

Returning to our main line, we soon pass under the famous town of Mardin, perched up in the mountainous crags that overhang the plain like the eyrie of an eagle. Mardin is the one place which held out successfully against the elsewhere ever-victorious arms of Timour.

From the ruins of the old citadel, a most extensive view is obtainable, and the range of the Sinjar hills which extend from Mosul to near Palmyra for some of the distance, being known as the Abdul Aziz Mountains, bound the southern horizon. Mardin dominating the plain in the manner it does, and being easily capable of being rendered impregnable, would form a most important position in the defence of the line, and no army advancing from the east could dare to pass such a post unless it were masked by a force far superior to its garrison; and, even then, as to surround Mardin is almost impossible, a daring body of cavalry having it as their *point d'appui* might so harass the communications of troops advancing either from the north-east or east, as to cause serious anxiety to their commanders.

South of Mardin, around Ras el Ain, are the settlements of a number of Circassians, and beyond them the mountains of Abdul Aziz and the tribes of the desert. Though the Circassians are as bad as their fellow-countrymen elsewhere, still they have some good military qualities, and proper discipline might furnish a valuable body of cavalry. The Arabs, trained in ghazous and raids and living under the open Heaven, have their perceptive faculties sharpened to the utmost, and would be most invaluable as scouts and to collect information. A man who can steal a mare from the centre of the encamp-

ment of a rival tribe, though crowded with dogs and cattle, could penetrate into any camp of ordinary soldiers, and bring away in his memory every material detail. On both sides, therefore, the holders of the line, if they also have had the tact necessary to make friends with their neighbours, would be possessed of local means of defence against any enemy.

After leaving Mardin we pass by the towns of Dara and Nisibin, ancient rivals and frontier posts of Imperial Rome, and her constant enemies, the Persians. Both are now only small places of no great importance; but, lying as they do in districts of great fertility and well watered, there is no doubt that they will, when once more in communication with the outer world, show signs of renewed vitality. Though at the time we were at Nisibin there was sickness there, all the surrounding districts were perfectly healthy.

From Nisibin we at first went along a plain, about which were dotted several villages and the ruins of more: many of the latter were quite of recent date; indeed, the Christian Chief of Asmaur told us that ten out of twenty villages inhabited by Chaldean Christians had been destroyed during the previous twelve months. After passing this district around Asmaur, we went across a country once inhabited and covered with towns, but now only affording pasture to the flocks of nomad Kurds or Bedouins, until close to the Tigris just above Mosul.

The whole of the country traversed between Urfa and Mosul was once populous, prosperous, and well cultivated, and it is only owing to the apathy of the inhabitants that wells and watercourses have been allowed to become choked up, and forests destroyed, so that what was once a smiling garden is now in parts, for some months of the year, a parched and arid waste.

In the wars between the Parthians or Persians and the Romans, armies, often consisting of over a hundred thousand men, traversed this country in every direction; and if what history relates of the luxurious camp-equipage of these ancient warriors be true, they must have been even more hampered and encumbered by non-combatants and beasts of burden than any modern force, and must have everywhere found grain, water, and forage in abundance. As matters are at present, it would be a difficult matter in extra dry seasons to march a force from Urfa to Mosul by this line, though, with very little trouble in the construction of wells, there would be no difficulty whatever. As far as I could judge from the appearance of the land and the dip of the strata, in no place would it be necessary to go deeper than from 70 to 80 feet, and usually a much less distance, before reaching water; the rock to bore through would be a soft, friable limestone, easily worked, but possessing quite sufficient cohesion for the sides of wells to stand without any artificial means of support.

Of course, if a railway were made here, the first thing to be done would be to dig wells. A certain number of labourers might be found on the spot; but a Christian merchant and contractor told me he could place 4,000 families, or about 10,000 working men, at any place or places between Urfa and Mosul, and engage to keep them supplied

with food whilst they should be employed. The cost of such labour, including food, should not be more than 1*s.* 6*d.* a man a day. The same merchant could also provide, more easily than any one else, carriage for stores and materials, and was so taken with the idea of a railway passing near him, that he said he would take 30,000*l.* in shares if it ever were made.

Mosul is now surrounded by a wall which was built a few years ago to protect it from the raids of the Shammar Arabs, but which would be a snare and delusion to its defenders, as it is so badly traced that long stretches of the banquette can be enfiladed by people lying behind the earth thrown up out of the apology of a ditch which surrounds it.

The barracks and Government buildings are outside the town, and might easily be made available for four or five thousand men. On the eastern side of the Tigris the mounds of the ancient Nineveh afford admirable opportunities for the construction of a *tête du pont* to protect the bridge across the river. Mosul commands a route to the north-east and east leading to Teheran and the Caspian, also one to Diarbekr and Jesireh, the great wool mart. Near Jesireh also are valuable coal mines which, of course, would prove of great importance, and it would be a question to discuss how best to link them to the line at Mosul.

At Mosul the question arises as to whether it would be better to cross the Tigris there, or continue on its right bank as far as Baghdad. If the river is crossed at Mosul a very much more difficult country would have to be traversed, two other rivers, the Greater and the Lesser Zab, would have to be crossed, and the railway would be open to raids on it from the east. If the right bank is followed, the railway is protected for its whole length by the river, and easy country is passed through, and the distance is much less than if the railway passed by Erbil and Kerkuk, the only real advantage claimed by those who advocate going to Baghdad from Mosul by the eastern side of the Tigris. Another advantage is claimed, viz., that on the east of the river the railway would be more defended from the Bedouins, but those who raise this chimerical objection forget that any of the railways proposed in those regions would be more or less exposed to such a danger if it did exist, and that the populations to the east of the river are just as likely or more likely than the Arabs, to damage a railway, whilst the Shammar Arabs, through whose districts the line on the right bank would principally run, are at present in alliance with and subsidized by the Turkish Government.

Between Mosul and Baghdad there are no difficulties worthy of the name, and if a railway were constructed and irrigation and agriculture encouraged, the country would once again become densely populated.

Baghdad is one of the largest towns of the Asiatic dominions of the Sultan, and is especially important to us as being so intimately connected with our Indian possessions. As the seat of the Caliphs, Baghdad, and before it the cities of Seleucia and Ctesiphon, was once the centre of the civilized world, where learning and arts, commerce and science, had progressed further than they had in Europe, and though

it can never be expected that she will regain all her ancient wealth and prosperity, still it may be confidently said that when the principal city of the richest province of Asiatic Turkey is once more in easy communication with the rest of the world, she will again become one of the greatest of marts.

Steamers from Baghdad to Basrah are now running, two English and six Turkish, besides which the Bombay Marine steamer "Comet" is at the disposal of the Resident. The difficulty of the navigation is such that it is rare indeed that the passage is accomplished in less than four days, and the cost of the double transhipment of goods, and the delays consequent thereon, would go far to neutralize the advantages gained by the railway. Baghdad can never, therefore, be a terminus—an important station she is and always will remain. As Baghdad cannot be a terminus, where shall we find one? Kweyt and Basrah have both been proposed; Kweyt is disposed of by the fact that it is on the wrong side of the Persian Gulf, and therefore when (as without any spirit of prophecy it may be asserted will be the case) the line is continued on to meet our Indian system, the Kweyt portion of the line would only serve a very small and very local traffic. Basrah is debarred by the fact that the land around it is so low and so easily flooded, and is so liable to have channels cut in all sorts of unforeseen directions by these floods, that the construction of a railway to that place would be costly in the extreme, and its maintenance scarcely practicable.

Where, then, shall we look for our temporary terminus? at Abushire, "the father of ports." I know the portion of the line I am now going to advocate has been condemned by Mr. Blunt, who travelled with his wife, Lady Anne, from Baghdad to Abushire (Bushire) by land, and who I have heard assert that it would be utterly useless to construct a railway there, that such a railway would be of no value and never pay. With all respect for Mr. Blunt I venture to differ from him, notwithstanding his personal and local knowledge of this portion of the line. A very large trade between India and Baghdad already exists, and even now people from Bushire go to Baghdad by sea in large numbers. The holy places of the Shiah Mahommedans attract enormous numbers of pilgrims; Samara alone is visited by upwards of 30,000 every year, and many a pious heir brings the corpse of his father to be interred in the holy soil. This traffic and the trade resulting therefrom would all be taken by the railway.

He says that the country is uninhabited and uncultivated, but complains of the number of rivers he had to cross. A river properly used in these latitudes means wealth untold to the lucky persons who can avail themselves of its waters, and if these countries are not prosperous at the present moment, it is not from any physical incapability or on account of soil or climate, but on account of the blighting misrule under which they have groaned for centuries. These very rivers, especially the Karûn, will be our greatest friends, and will enable us to transport our *matériel* to the required positions at a minimum of time and cost. From Dilam, where the coast should be reached, the shores of the Persian Gulf should be followed as far

as Bushire. Here for the time the railway might rest, but as the Eastern Question develops, so will the continuation to Kurachi and a line from Mosul to Herat and Kandahar become more and more plainly necessary. As we have to consider, in a line of this sort, its future developments, and as no doubt it is destined to form one system with the railways of India, it is right and fitting that the gauge should be that of the trunk lines of the Indian Empire. One great Power, in her consciousness of the danger of more civilized nations penetrating her shell, has deliberately broken the gauge at her frontiers; we should benefit by the lesson thus taught, and in constructing these lines make them more readily available to ourselves, to whom they are of most importance, than to possible rivals.

Bushire and Tripoli, at a comparatively small expenditure, may be made into good harbours and quays, and wharves could easily be constructed at both places so as to avoid the necessity of using cargo boats.

I have thus endeavoured to trace the course of what I hope may be the first section of the Indo-Mediterranean Railway. Instead of its being a rival to the Suez Canal it would prove a most important ally, and would enable us to thwart any attempt on our present lines of communication with India.

By steamers from our now first-class port of Kurachi to Bushire, troops could be conveyed from our Indian possessions to the railways which would place them in the commanding positions in the battlefields of Armenia, there to find themselves met by their brothers in arms arriving from Cyprus and other *places d'armes* in the Mediterranean.

At Cyprus we have a port, Famagusta, where ironclad ships could lie in perfect safety only six hours distant from the terminus of the railway, and from Cyprus we could at a moment's notice transport men to stop revolts, barbarities, and atrocities in the greater portion of Asiatic Turkey. The knowledge that we could do so would prevent horrors such as have, in Bulgaria and Roumelia, disgusted the civilized world, and which still leave their poisonous effects behind them.

If the Suez Canal should ever be blocked (a matter by no means difficult of accomplishment), or Egypt and the Canal fall into the possession of a hostile Power, it is to the Indo-Mediterranean Railway that our Navy and Army would have to look for assistance in maintaining our wonted communications with India, or to recover our control over the great highway for ships.

I fear this has been a long and wearisome paper for those who have listened to it, but railways do not belong to the days of romance and comedy, but to the work-a-day world of the 19th century.

Lieutenant-Colonel BATEMAN CHAMPAIN, R.E.: It seems to me that this question is one of very great importance, and that you, Sir, and everyone present will be glad of any light, however small, that can be thrown on the general question raised by the paper to which we have listened. I have twice ridden up the Tigris Valley from Baghdad, once to the Black Sea, and once to the Mediterranean along a great part of the road that has been so well described by Commander Cameron this

afternoon. I merely mention the fact of my having personally visited the country as an excuse for my venturing to say one or two words. If Asia Minor or Mesopotamia belonged to the British Government, I, for one, would consider it our bounden duty to make roads and railways in every direction. I agree with Commander Cameron in thinking that it is one of the richest countries in the world, and everyone knows that it has been suffering from ages of misgovernment. But I would, as far as my own opinion goes, protest, as strongly as I have done before, against the idea that the Euphrates Railway or the Tigris Valley Railway would be a really good and sound means of military communication between England and India. Of the two, decidedly I would prefer the Tigris Valley, but I object to the whole scheme, on grounds which I will presently state. I prefer the Tigris route because along the Tigris there are towns and places of commercial importance, whereas on the Euphrates there are none; between Biredjek and Bassorah there is hardly a town or even village of any note. On the other line there are Diarbekr, Mosul, Arbil, Kerkuk, and Baghdad. Those places could, no doubt, well support a small local railway. But if the railway be constructed in a costly manner, as a means of military communication, it would never pay, and consequently I believe it would fall into slovenly management, and if ever it were worked it would prove a thorough failure. I believe no through traffic would pass over it, even in time of peace, as no merchant in the world could afford to employ that route. Supposing the line were continued only as far as the head of the Persian Gulf, the transhipment there and at the other side would cost an enormous amount of money, and seeing how little is paid for freights now-a-days to and from India, it is absurd to suppose that any kind of merchandise would pay the enormous extra cost that would be entailed, simply to gain four or five days, and I do not think more would be gained in practice, because the line could not be worked at express speeds. Scarcely any through travellers would use the line. The climate is for three or four months in the year exceedingly pleasant, but anyone who knows what it is to be cooped up for three or four days in a railway carriage, even in these temperate climates, will admit that such travelling is exceedingly uncomfortable, even when one has a whole compartment to one's self. But to box up twelve or thirteen soldiers in a third-class carriage, and carry them through that arid, dusty country, would be nearly impossible for nine months of the year. The health and strength of the men would be destroyed unless you could break the journey two or three times, and in that case you would lose all the advantage this route professes to offer. The thermometer has been known to register at Bassorah as much as 126° in the shade—an excess of heat which could not be borne by men packed closely together. On board ship, great heat is bad enough, but it is supportable. Life on the Red Sea is, no doubt, at times unpleasant, but to be cooped up in a railway carriage for a long journey like that, from the Mediterranean to the Persian Gulf, would be intolerable. The worst part of the whole journey to India is thought by many to be the railway from London to Brindisi. Crossing the Isthmus of Suez is also generally looked forward to with a certain amount of distaste, and the bother of disembarking and re-embarking at Alexandria and Suez is very great. That being the case, I assert that the line under discussion, unless it is to depend entirely on its local traffic, cannot be pronounced a desirable undertaking. With regard to going down the river from Mosul, I am certainly inclined to think that the left bank is the proper one to follow; you traverse a much richer country and pass through several important towns. As to the Arabs and Kurds, though I have nothing to say against the former, still they are a difficult people to control, and nobody can calculate on making the camel journey from Baghdad to Damascus without being robbed; but, generally speaking, anyone can ride, as I and others in this room have done, through the Kurd country without molestation, and that is the line which has always been chosen by the Turkish Government for its post road, its telegraph, &c. Finally, I cannot agree with Commander Cameron in his remarks on the eligibility of Bushire as a port. No ship of any size, drawing more than twelve or fourteen feet of water, can get within three miles of the place.

Mr. Scott Russell, F.R.S.: As I have had the pleasure, I may call it, of examining that country with the view of carrying through it a railway which might he commercially profitable, and which it might be strategically wise for England to promote, I will venture to make a few remarks upon this paper, and I will call attention to the

necessity in dealing with this subject of taking three quite distinct views. First, you must consider the relation of this railway to through communication through Europe with the Indian Empire. You must then consider it with special relation to English interests. And, lastly, you must do what is perhaps still more difficult for us to do, consider it with a view to developing the interests and the prosperity of the countries through which it passes. I mention all this, which appears a complicated problem, because I was compelled to think of it, whether I chose or not, in all these different aspects. I was asked by the representatives of several Governments to tell them what, after examination, I considered the best route from Belgrade to the Persian Gulf. As an Englishman, my feelings did not stop there. We English have too many friends in India not to think, when there is any talk of such a communication, how we can easily and most conveniently visit our friends in India or have their visits paid to us, and, therefore, you will pardon me when I say that I could not make up my mind to stop at the Persian Gulf, and was obliged to go on until I got to Kurachi. I examined that line (1) as a professional *engineer* who, in his early life, was engaged in the construction of railways, before he began to construct steam ships. (2) After that, I was obliged to look at it as an *Englishman*; and, (3) strategically. I, therefore, went to our most distinguished strategist at the War Office, Sir Henry Storks, who I am sorry to say is now dead. He was good enough to initiate me into all his views with regard to the strategical value, advantages and disadvantages of certain lines of railway in Asia Minor, in Turkey, and in Persia. I discussed with him the whole of these questions, and received from him the best possible advice. You may think it curious that I should have got all this advice from the various States who were interested in this railway, but I tell you that there was no merely mercantile object in view; it was then entirely an international object: and for that purpose I made the investigation. I therefore looked at this railway, which is now proposed, and which, if you please, I will call the "Mediterranean and Persian Gulf Railway," in its relation to the great through international communication, and I found that, although it might be very good as a local railway, yet, as an element of the through communication, it was not all that I could desire. With regard to Commander Cameron's special line, there are qualities in that line which I have not seen in any others, and they are these: that the line he proposes, although not of high value as a through independent line, would, to a considerable extent, be a better adjunct to a general international communication than any of the other lines I have seen proposed, called "Euphrates Valley Lines." In the system of international railways, which I was compelled to examine, we came to certain points from which we sent off branch lines exactly resembling those which are laid down by Commander Cameron. Allow me to say, further, that you must consider this international railway in a strategical point of view. I had the advantage of the assistance of one of the most distinguished railway authorities in England, and a Royal Engineer of great eminence, and also of the assistance of an engineer Officer in the service of the Turkish Government. I had all the plans and surveys of the different Governments of Europe communicated to me, and where I did not find the surveys satisfactorily executed by other people, I went personally, accompanied by the friends I have named, and examined those districts with reference to their convenience and practicability. I can quite confirm what Commander Cameron has stated, that those ways up to the high level of the central plateaus, which have hitherto been called impracticable and have been avoided, are ways which are easily practicable, just as the line which he has selected is, and can easily be reached and passed by the ordinary standard of steepness of railway which we are accustomed to use in England. Therefore, I am satisfied that on no merely engineering ground can Commander Cameron's selection of line be considered at all an impracticable or an unwise one. There is one point, however, on which I rather agree with Colonel Champain, that is, I do not like that line from Mosul to Baghdad. I will not go through the reasons, there are very many, but I do not like it, and I would prefer his Tigris Valley portion for that part of the line, instead of Commander Cameron's. I do not know what his reason is, but my reason for preferring the Tigris is a very strong one. I think it agrees with Colonel Champain's. I would entreat all those Officers and members of this Institution, who interest themselves in this subject, not to

commit themselves to any particular portion of this or other lines, until they have considered it in the larger view of a through route to India, and I would also entreat them to take another view, which does not seem to have been taken. If in each of those countries you have to pass through, you will begin by laying out a system of railways, designed in the first instance for developing the wealth and commerce of these individual countries, and if you will first of all study the structure of the mountains and the valleys of that country, with a view to the formation of paying local railways, you will find, when you have laid out a systematic group of railways for Turkey and Asia Minor, and for Persia, and when you have systematically connected our Empire in India through Afghanistan and Beloochistan with Persia, that you have almost got a perfect international line which could not be better laid out for an international line than it has been, when you look at the necessities of developing the country through which it passes. If we have performed (as we have done) the great *rôle* of setting an example to the world of the development of railways, we have also taught this great lesson, that it is folly to lay out bits of railways, and that there is no wisdom in the making of railways but one, namely, to develop an extensive and general plan in the first instance, and then to carry out that larger plan by degrees, after it has been systematically matured; and I say, with regard to these railways, I am satisfied that you can develop the resources of all these countries through which the railway has to pass, in such a manner as to add enormously to the wealth of civilized Europe, and the well-being of the inhabitants, provided you will take all these points into consideration, including the wealth of the country, including our convenience, including strategical defence, and will not commit yourselves to any one branch until you have developed it as a part of the whole. Allow me, in conclusion, to say this one word. I know that if England will take the lead in this matter, there are other States in Europe who will give her cordial assistance in money, in political arrangements, and in support of every kind.

Mr. J. L. HADDAN, M.I.C.E.: In discussing this admirable paper, as one acquainted with every inch of the ground which Commander Cameron has lately gone over, I must express my admiration at the remarkable way in which both in his book and lecture, he seems to have picked out the wheat from the chaff; a very difficult task when we consider that, owing to the short period he was in the country, a great deal of his information must have been necessarily obtained at second hand. No one, be he the best railway engineer living, which Commander Cameron does not pretend to be, could have hit upon a better line, from a railway surveyor's point of view, than he has done. It is certainly practical, as Mr. Austin's more elaborate surveys demonstrate, but nothing perhaps proves the inelasticity and weakness of ordinary railway construction more than the fact that the easiest line is always sought for, and not one which is necessarily either commercially or strategically the best; in this case the easiest route may be inadmissible, because it does not, in Sir John Adye's opinion, prove itself strategically of value, while in Mr. Andrew's opinion it is not commercially the best either. The whole of the coast of Syria, between Alexandretta and the Suez Canal, is most formidable for shipping, there being no harbours of any kind; but as if to make up for it, Nature has created, from Aleppo on the north down almost to Egypt on the south, an inland highway, along which you could almost drive a coach and four. Part of that natural highway is cleverly followed by Commander Cameron, viz., from Homs to Aleppo, and he thus taps the best part of the country. With reference to strategy, I beg to point out an important change in the question, one which the older advocates of the Euphrates Valley Railway, probably from long habit of one line of thought, have not noticed. They seem to forget that the bearings of the case are completely changed by the acquisition of Cyprus. It is no longer necessary, from a military point of view, to bring England and India into direct communication with each other—Cyprus being our representative now. It becomes simply a question of forming a triangle between Cyprus, Bayazid (on the Russo-Perso-Armenian frontier), and the Persian Gulf, so that from either end we can defend the Asia Minor frontier, as we are bound to do by the Anglo-Turkish Convention. This three-armed or Y-shaped line might follow the Cameron route from end to end, bifurcating at Mardin and passing through Diarbekr to Bayazid, which frontier town approaches it at right angles, a most important point in strategy. With

reference to sending large bodies of troops by railway, a great deal of misapprehension exists as to the powers of a railway both as regards its speed and capacity. The late Colonel Home, than whom there is no greater authority on military transport, showed that it would take longer to send an army corps to York from London by railway than it would for them to march, although there are several double lines in the example he quotes, and only a single line in this case. Single line railways as a military means of transport are therefore of little use, and are not fitted to carry any large number of troops, for to box men up in the way Colonel Champain described would, of course, be quite impracticable except on an emergency. Referring for illustration to the Afghan campaign, it will be found that the enormous number of camels and mules employed transported stores for the troops, but not the men themselves, and the value of this line would be confined to doing similar duty—at far less expense—and with permanent advantage, creating means of transport instead of destroying them. Even for Cyprus, where is the grain to come from to feed that country but from Syria? It is a great mistake for the advocates of this line to talk of the profit to be made out of through traffic. Excepting for the mails the extra transhipments alone would be fatal if the bare fact did not suffice that no goods can afford more than 400 miles of railway transport. except the line in question enjoys a monopoly of route, which is not the case here. Should the Canal be blocked, then having this last point of transhipment, on the eastern side of the Canal, so much nearer to India as the Persian Gulf is than Suez, enables the few ships available on emergency in Eastern waters to do as much carrying work as the larger margin of supply the Mediterranean always affords. From a "transport" point of view speed is of no value—regularity is what is wanted. Speed only affects the first delivery, and regularity is necessarily jeopardised by hurry. A single line like this would not carry through goods at a greater speed than one mile an hour, counting the full time they occupied the company's premises. In France the legal rate of transit for heavy goods works out but a little over half a mile an hour,[1] and at a corresponding diminution in tariff even a slower rate is accepted. Speed and cheapness cannot co-exist on a railway; they *may* do so on the sea where there are no differences of level to be overcome. Having agreed that the Indo-European line is necessary, the next point is the labour question. Can you get men? I say most emphatically no! From an economical as well as a philanthropical point of view, a great many people hold that making railways by hand is a first-rate occupation for the peasantry. It has even been proposed to adopt these tenets in Ireland, the population of which is 169 to the square mile; but first-rate politicians have agreed that it is suicide in that country to take a man away from his plough. Now, we have the same question in Syria, but under less hopeful circumstances; for there the population is only 32 to the square mile, not enough to cultivate the soil at the best of times, while there are thousands of acres only wanting men to cultivate them to produce many hundred-fold for themselves and for the State whose revenue is essentially derived from the soil Mr. Consul Skene is of opinion such works would grievously affect the revenue. What worse investment can be imagined than employing in such a case manual labour in cutting off the tops of mountains and filling up the valleys? If you make up your minds to construct a railway in such districts, you must either use mechanical means for constructing earthworks, and even then none of the works will be completed simultaneously, or you must do away with them altogether, and the latter I have shown to be quite possible. One notable fact with reference to the construction of military railways, necessarily made by hand, is this: that a railway made by hand has from four to five times as much stuff in it as a railway made with the usual English plant, viz., of rails, waggons, and engines, &c. If you buy two chairs or tables, one made by hand and the other turned out by machinery, no doubt there would be the same amount of wood in both; but in railway construction it is not so, for in making a railway by machinery the waggons transport the earth from the cuttings to the banks, and it is therefore the custom in our profession only to pay for one, as the two birds are killed with one stone. But when you make a railway by hand, you cannot transport the stuff even a few yards, and every load of earth taken from the cutting must be thrown

[1] Alfred de Torville. "La Transformation des Moyens de Transport."

away and wasted, while every load of earth required for the banks has to be sought for afresh and scraped together perhaps from a considerable superficial area. Owing, moreover, to the want of mining tools to blast the rocks with, cuttings are reduced to a minimum, and the banks correspondingly heightened, *i.e.*, practically doubled in depth. Now, since a 20-foot bank has four times as much in it as a 10-foot bank, it results that a railway made by hand will require about four times as much labour as if made by machinery; and in addition, if in England, where coal, iron, and mechanical talent are drugs, 50,000,000*l.* of railway capital pays no dividend, such works can hardly be expected to flourish in Mesopotamia.

Lieutenant-General Sir JOHN ADYE, R.A., K.C.B.: I am desirous of making a few remarks upon the lecture we have just heard by Commander Cameron, and am sorry to say he has not convinced me that, either in a commercial or in a military point of view, it would be desirable that we should assist in making a railway through Asiatic Turkey as a means of communication with our Empire in India. As regards the commercial aspect of the question, our goods are now transported in vast quantities from the ports of England with ease and facility by sea through the Suez Canal, and within a month are landed in Bombay without transhipment, but if we adopted this proposed line, we should have to land our goods on the coast of Syria, where there are no good harbours, and where the country is unhealthy, and after a long journey by land should have again to embark them at the Persian Gulf, a country equally unhealthy and devoid of good harbours and facilities. Would that, in a commercial point of view, be a desirable arrangement? Let me read a short extract from a letter that appeared in the *Times*, on the 11th of December, 1879, signed W. H. I. The writer said:

"As a commercial enterprise the formation of such a line would, I venture to say, " be a dead failure and prove sadly disappointing to any persons who had been foolish " enough to embark capital in the undertaking in hopes of a return. That, after a " steamer has been loaded and despatched from London, Liverpool, or Glasgow, the " whole of the cargo should be turned out at Beyrout or some other Syrian port, there " loaded in railway trucks for conveyance through Mesopotamia, discharged out of " those trucks at a port on the Persian Gulf, and a second time loaded on board a steam " ship for India, instead of being allowed to proceed to India direct in the original " vessel which had sailed away from England, is an idea so preposterous in the eyes of " all men of business that it may almost be dismissed without comment. Have your cor- " respondents ever calculated, or attempted to calculate, the enormous expense which " would be created by this extra handling of goods (to say nothing of the loss that " would be caused by breakage or exposure), and compared this expense with the " trifling gain which might possibly be derived from the shortening of the transit by " five or six days?"

In a military point of view, I think there are great objections to the proposed route. In the first place, our troops are now transported with ease and comfort by sea in four weeks to Bombay, and it appears to me that that is the safest and most prudent course which we, as a great naval Power, could adopt. But if taken in the way proposed, we should have to land our troops on the coast of Syria, and, after a long fatiguing journey of many hundred miles, should have again to embark them where there are no facilities, in a very unhealthy corner of the Persian Gulf. But there are greater military objections than that. This line of railway, if completed, would not belong to England, but would traverse the territory of another Power—that is, Turkey. Surely it is not desirable that we should be dependent on another country for the line of our military communications with our Indian Empire. Another still greater objection is, that this line of railway would be open to danger at all points, while the Suez Canal is practically free from attack by land. By adopting such a proposal as that now under consideration, we should therefore not only be dependent on Turkey, but our line of military communications would run across the front of, and be in comparative proximity to, the armies of another great Power—that is, of Russia on the Armenian highlands. Surely such an arrangement would not commend itself to the judgment of military men. In my opinion, therefore, the route would commercially be a failure, and in a military sense it would not only be useless, it would be a danger.

Captain J. C. COLOMB, R.M.A.: The last speaker has anticipated what I wished

to say. The general question is that which has first to be considered. We have drifted into a good many mistakes in our time; we all know that, we have only got to consider what our Empire is at this moment, to know it. We have a telegraph cable the wrong side of Africa, and we have our communications between two extremes of one of our great Colonies passing through a foreign country; therefore, I think of all things in considering a great question like this, we should really be careful to clearly understand whether in its broadest sense, the proposed line is or is not desirable from an Imperial strategic point of view. And I must say, having looked into these questions, I entirely concur with Colonel Champain and the last speaker. I will not take up the time of the meeting by giving reasons which have already been given, but I should like to ask Commander Cameron if he would be kind enough to answer one question. In making a railway what we have to consider here is its strategical or military aspect purely, because commercially we have nothing to do with it, for this reason: that if it is a commercial speculation worth anything, we may depend upon it commercial men will take it up. In this Institution, I take it, we must only look at it from Imperial strategical ground. I confine myself very briefly, therefore, to this one remark. Commander Cameron spoke in rather an offhanded way, I think, considering our military resources as regards men, and when he said that if the Suez Canal was blocked, of course troops from India and troops from England would meet at points in that proposed railway. I should ask him to consider, Have you got the troops? Are you going to make a great English line for strategical reasons without making preparations for its adequate defence? That is a very serious point. He said if the passage through the Suez Canal was stopped, we could carry on our traffic by that railway; but that, I consider, entirely depends in what way the Suez Canal is stopped. Is he contemplating the cutting of the sea communication by Alexandria, or between Alexandria and England, because if so, what becomes of your sea communication with the Mediterranean terminus of this proposed line? It appears to me that you would divide your power of defending your line of sea communication. We should never permit the stoppage of our communications through the Suez Canal; and to make your railway because you are content to think we may lose that route, is to my mind a mistaken policy. I simply ask Commander Cameron to explain how that land line of communication would enable us to recover our control of the Suez Canal when the control of the Suez Canal is really a naval question.

Mr. C. E. Austin, C.E.: I wish simply to say a few words on the commercial view of this question, for I know very little about the strategical part. With regard to the heat in railway carriages in these climes, I have had some experience in Brazil, and I did not find it so extremely oppressive as Colonel Champain thinks it would be. In Brazil we travel very easily. In Smyrna, again, where the heat at some times of the year is very oppressive, we travel very well in railway carriages, and we find no difficulty in so constructing our carriages as to keep the people cool inside. During the Russo-Turkish War we carried many thousand soldiers on the Smyrna and Cassaba Railway. With regard to the bugbear which drives all our commercial men away from railway speculations in Asiatic Turkey, so that without the aid of Government, and a guarantee on the money expended in the construction of these lines, they never will embark in them, it is the idea that you cannot work with the men of the country. The Kurds are tabooed; the Circassians are said to be people nobody can control. Midhat Pasha has been constructing roads in Asia Minor; and last April I had the pleasure of laying out the commencement of the Tripoli line, three miles in length, from the port of Tripoli to the town. I accompanied Midhat Pasha from Beyrout to Tripoli, whither he went more especially, because they told him 40,000 Circassians were collected at Tripoli, and there was much fear that they would become unmanageable. He went there, and found 5,000 Circassians and Tartars, whom he set to work to make a road from Tripoli to Homs. We tried the Arabs (the people of the country), and compared them with the Circassians; but the Circassians did much more work than any Arab, and they were taught with the greatest ease. They are the people on whom Midhat Pasha depends for making his carriages, and working the carriages on his roads. In every country that they go to, the Crim Tartars and Circassians introduce the carriage which does not exist in those coun-

tries. With regard to the Kurds; we have employed on the Smyrna and Cassaba Railway, bands of Kurds; they are admirable labourers; they are much more easily taught than Greeks and Turks. The Turks are very good labourers too; but all the men we are the most afraid of, when they are turned to work, prove to be the best workmen we have. The best zaptiehs all over Syria are Kurds; the best country proprietors are Kurds; wherever you meet a Kurd you like him. I had a zaptieh with me, a sergeant, who travelled with me a long while. That man was a well-disciplined soldier; and although I was an Englishman and a Christian, and he a Mahommedan, he would come and pull off my boots in the evening, and would do any menial service for me, which an Arab would not willingly have done. He considered me as a friend of his master, and did not think of my religion in any way. With these facts in view, we must naturally infer that the Bedawee who inhabit the nomad districts of Syria and Mesopotamia, through which the proposed railway must pass, and who are only nominally Mahommedans, and much more liberal in their tenets than Mussulmans, would rather aid than hinder the construction and maintenance of the line. Then, as to commercial profits, I must say, Commander Cameron's line, comparing it with the Euphrates Valley Railway from Alexandretta, is a possible line, whilst the other is an impossible line. The gradients on his line are moderate, and there are no gradients against the traffic; whilst on the Alexandretta line it is stated that there are gradients of 1 in 13. The country being an agricultural country, the heavy traffic will consist in exports; and, in making a line of that sort, we must have no gradients against the traffic to the shore. The quantity of our import goods will be small in comparison, but it will be more valuable and pay more for carriage. The line proposed by Captain Cameron leaves out of the scheme a very large town, namely, Damascus. The traffic between Damascus and Baghdad is very large. Thinking, as I do, that there is not the slightest difficulty in setting these tribes to work, whether nomads, Arabs, Kurds, or Turks, I cannot see why you should not save 280 miles of railway, and go straight from Homs to Baghdad. Baghdad is the great emporium of the East, and the great object is to make the most direct communication with the west from that great emporium and the Persian frontier. By doing so, you bring the traffic to Homs, which, in ancient times, was a very large town, and a very great centre of commerce. From Homs, the goods brought from the East can be dispatched over good roads either to Damascus or Aleppo, and the straight railway is sure of the traffic from Baghdad to both these towns as far as Homs. There is no difficulty in running across the steppes of Mesopotamia. They are as flat as a table, so that the line will cost comparatively little, and the traffic expenses be very light. However, into the details of construction this is not the moment to enter.

Mr. Trelawney Saunders: As you are quite aware, the naval power of this country can be exercised up to the shores of Syria on one side, and up to the head of the Persian Gulf on the other; and the simple question is whether it is desirable to complete the missing link, and connect those two points by a railway. In this Institution you may dismiss questions of commerce. If that missing link is to be supplied, you will probably conclude that it should be by the shortest and safest route. The author of the present paper has endeavoured to argue in favour of the Tigris as against the Euphrates, which unquestionably marks the shortest route. He has endeavoured to persuade you that the Tigris is preferable, because it has more large towns upon it. But we must all recollect that we are not dealing in the present case with simply the supply of railway communication to certain towns in the Turkish dominions, but with the question—how this country and India can be most easily connected. It is admitted that we already have a line of communication *viâ* the Suez Canal. Very good; but is it desirable that we should depend under all circumstances upon one line of communication only, for you may almost put the line by the Cape of Good Hope out of question? Most people agree that it is not desirable to confine the communications of a great Empire to one line, and it is contended that the line of communication by the Persian Gulf and the Mediterranean should be made as an alternative to Suez. With regard to the present distribution of the population in the Tigris and Euphrates Valley, it must be in the remembrance of every one who has studied this subject that the time was when the Euphrates also had considerable towns at very short intervals all along its

banks; and there can be no question that with the establishment of a railway and the restoration of good government in Asiatic Turkey, the towns on the Euphrates would revive again. In fact, wherever you carry such a line of railway, population will follow it. It must be presumed that great facilities are offered by the Euphrates line, to account for the persistence with which its claims have been advocated for the last twenty years by Mr. W. P. Andrew. There must be good ground why a man of his railway experience and good judgment should so persistently adhere to that opinion. The Euphrates is not only the shortest line, but by keeping to the south bank, there are no affluents to cross, and having no rivers to cross, there are no bridges to make, nothing but a plain to traverse. There is also another advantage, to which I may point, inasmuch as it has been alluded to by a previous speaker of great eminence, I mean the advantage of having interposed between your railway and any enemy advancing from the north, two great rivers, which would certainly be a great protection to the line south of the Euphrates. But there is a condition preceding that that has to be borne in mind in forming any opinion upon this question, and that is the following. No great public work could be undertaken in Asiatic Turkey in the present disturbed state of its administration. Therefore it is to the establishment of good government in those countries that everyone who is interested in opening up and improving communication through them with India should direct his mind at this moment. Everything should be done, I contend, to support any Government (I care not what party may be in power) in introducing into these regions, that were formerly the finest and fairest and best of the earth, that have still the natural fertility and productiveness and the industrious populations that would make them again the seat of wealth, and that need nothing but good government to restore the prosperity that made them formerly the seats of great Empires—on that point, the restoration of good government to those countries, already the opinion of the Powers of Western Europe has been brought to bear with great unanimity, and we should allow no differences of faction, no differences springing merely from political partizanship, to put difficulties in the way of that great object.

The CHAIRMAN: I hope we are not going into any political questions in connection with this railway.

Mr. TRELAWNEY SAUNDERS: I am arguing that we should all unite in promoting good government in Asiatic Turkey, and following upon good government, you may rely upon it, all questions of railway communication will very soon settle themselves. Whether you have a line by way of the Euphrates or Tigris, sooner or later that line will form a part of a general system of communication, which will connect Constantinople and Smyrna, as well as the ports on the Mediterranean, with Mesopotamia, the Persian Gulf, Persia, and India. A certain boundary has been fixed on the frontier of Armenia, which we are engaged to maintain. Another boundary has been fixed upon the River Oxus, which we have defined, and are concerned in maintaining. Why are those boundaries fixed? They are fixed as barriers, beyond which a certain Power must not advance southward. But there is an interval between those two fixed barriers that remains unprovided for, namely, Persia. Is it intended that in that interval or through it any hostile Power may advance to the Persian Gulf, or to the mouth of the Euphrates, or to any other point between India and the Mediterranean that will suit its purpose? I think not, and therefore it must be clear and obvious, that whatever policy is directed towards the Armenian barrier at one end and the Oxus barrier at the other, must also be directed to the Persian link that lies between those two barriers. That is a matter necessary to be borne in mind, and to be brought into action, before you can connect India through Persia with the line of the Euphrates Valley. I am glad to find my friend Mr. Andrew adhering to the Euphrates Valley line, and if that line is to be extended to India, the ground must be made sure in the interval that lies through Persia.

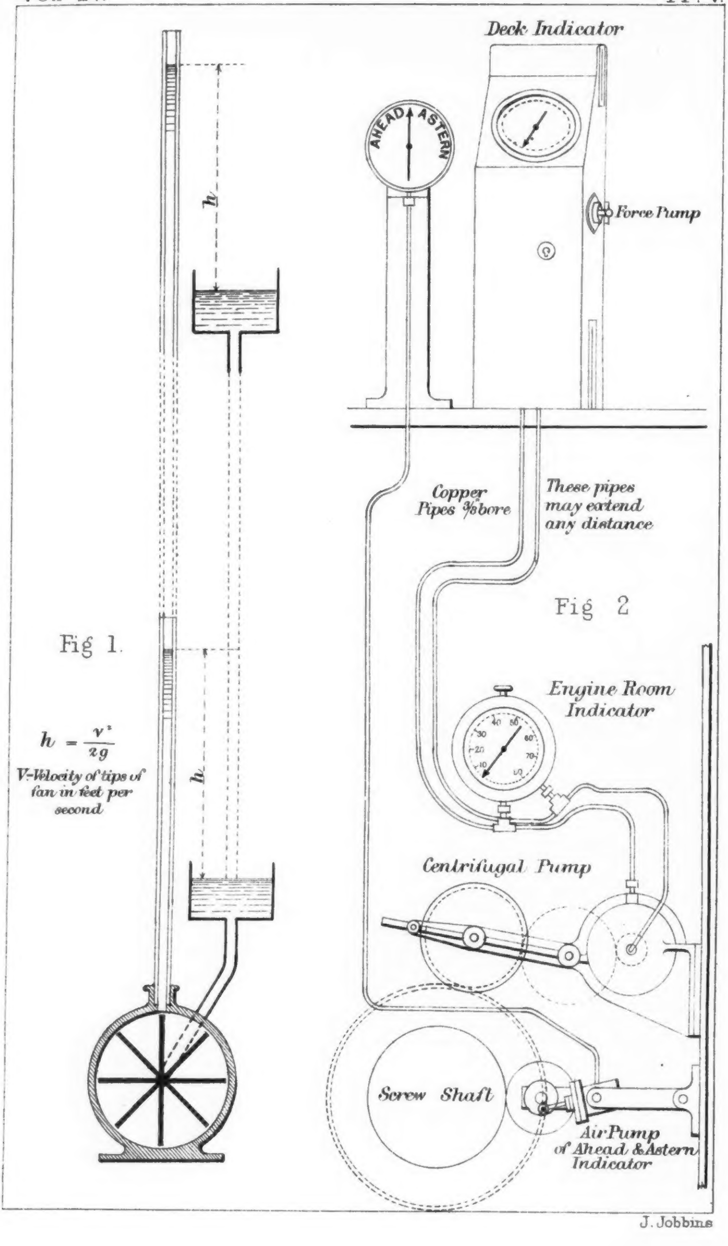
Commander CAMERON, in reply, said: Colonel Champain talks about the local traffic. I never would expect any railway to be paid for by its through traffic, but I believe the construction of the railway will attract people there who will settle on the ground and cultivate it, and will give us such an enormous traffic as will give a very good return on the railway. At present there are 400 tons, without the Aleppo

trade, which comes from the line by Homs and Hamah every day, and goes coastwards. A short way further back, wheat can be bought for five to six shillings a quarter, and it is delivered on board ship at over forty shillings. I utterly put on one side any idea that any traffic by the Suez Canal is to be diverted on to our own line; it is to assist the Suez Canal, and I believe the opening of that railway will cause increased traffic through the Suez Canal. As to Bushire having no harbour, and ships of any draught having to unload three miles out, there is a little bar which might be dredged, and then there would be thirty feet of water close up to the town. We cannot make harbours without spending money, and if we are to have a great scheme like this, we must pay for making harbours. There is a very good opportunity for making a good harbour at Bushire, and also a magnificent harbour at Tripoli. I agree with Mr. Scott Russell about the railway going from Constantinople. I do not think for our mails it is good to cross too many frontiers, but if the shortest route is by those frontiers, *perhaps* it may prove best to cross them. If we cannot carry out the whole of this international scheme, why should we not make that section which is most important to us nationally, and let the other follow hereafter? Mr. Haddan talks about mechanical works in a railway. I suppose if we go out there, we shall employ the latest developments of mechanical science. The population are doing nothing for many months in the year, and a great portion of them are stowed together miserably in the towns, on account of taxation, who would, by the fact of this railway being constructed, be first drawn out in the open country to be constructors of the railway, and afterwards become cultivators of the ground. As for the troops, of course the right way for our troops to go to India for all ordinary purposes is by the Canal; but if this line goes to Mosul, and I hope it is going to Persia some day, we may some day have war there, and then, by giving us the opportunity of bringing stores to such advanced points as Mosul and Diarbekr, the principal point in the defence of Kurdistan and Armenia, this railway will be of value to us. Then there is another thing. I never contemplate losing the command of the Mediterranean. I do not believe that England will ever lose the command of the Mediterranean or any other portion of the sea, but we know that dynamite and gun-cotton are easily conveyed to the most extraordinary places, and in ten minutes' time anybody going through the Suez Canal might block it so that it could not be open for six months. It might happen that, at that particular time, all our ships might be on this side, and then, although we might take troops across the isthmus by railway, we should not have ships to carry them on. But if we could take them up to Bushire, we might, in the mean time, telegraph to India to send ships. In answer to Captain Colomb, it is a great thing to be able to convey small bodies of troops rapidly, and thereby make them equal to large bodies of troops, that cannot be conveyed so rapidly. As to Kurds and Arabs, I may be prejudiced in favour of the Arabs. As for a Kurdish servant pulling off one's boots, I have gone into an Arab Shiek's tent, and he has pulled off my muddy riding boots himself, and you do not find hospitality like that in every place.

Mr. Austin: I meant to say these were the people tabooed; the Arabs most likely would be better than they.

Commander Cameron: Mr. Saunders still goes with Mr. Andrew. Now, I admire Mr. Andrew most thoroughly, but, at the same time, I must differ from him entirely. Iskanderoon is not a harbour, and a summit level of 2,200 feet has to be ascended in seven miles. A great portion of the Euphrates Valley is barren, and the population cannot live, while history tells us that, when the Emperors Julian and Cyrus the younger descended the Euphrates for a large part of their march, they were dependent on their flotillas for supplies. As for having two rivers instead of one to defend us, I should be very much ashamed if we wanted two instead of one; I should be very glad to use the Tigris by going down the right bank, but to go and put 200 or 300 miles and another river between us and a possible enemy, and leave a good position, I should be ashamed to run out of the way like that. Colonel Chesney quoted here, in July, 1857, "Europe is no longer the world. The key to "the possession of the world is the Valley of the Tigris, and not Constantinople." I hope that this railway will come to pass, and give us the command of that Valley of the Tigris.

The Chairman: I am sure I may return our best thanks to Captain Cameron for his very instructive paper.


Deck Indicator
AHEAD
ASTERN
Force Pump
Copper Pipes ⅜ bore
These pipes may extend any distance
Fig 2
Engine Room Indicator
10
20
30
40
50
60
70
80
Centrifugal Pump
Screw Shaft
Air Pump of Ahead & Astern Indicator
h
Fig 1.
$h = \frac{v^2}{2g}$
V=Velocity of tips of fan in feet per second

J. Jobbins

Monday Evening, February 2, 1880.

Rear-Admiral R. VESEY HAMILTON, C.B., &c., Member of Council, in the Chair.

TOWER'S REVOLUTION INDICATOR, AS INTRODUCED INTO HER MAJESTY'S NAVY.

By Mr. Beauchamp Tower.

I propose, first, to give you a short sketch of the history of my "Revolution Indicator," because I think that, by carrying you along the same path that I followed myself in contriving it, I shall more readily bring you to a true apprehension of its principles.

Ten years ago I had the privilege of being an assistant of the late Mr. Froude's, while he was erecting his works for the Admiralty experiments at Torquay. A want arose for an instrument which would accurately indicate at a glance the speed of the engine which hauled the models along the experiment tank. For this purpose I connected a small centrifugal pump, containing a fan with radial arms (Fig. 1) to the engine, a glass pipe, about 5 feet high, was connected to the delivery of the pump, while the centre or suction of the pump was connected to a small tank. The tank and centrifugal pump being filled with water, when the engine, and consequently the centrifugal pump, was set in motion, the water in the glass pipe rose above the level of the water in the tank. It was found, by experiment, that the height of the water in the glass pipe above the water in the tank was always exactly what theory predicted, namely, such that a falling body falling through the height would exactly attain the velocity of the tips of the blades of the fan. For example, a body falling through 4 feet attains the velocity of 16 feet per second, therefore, supposing the centrifugal pump is driven at such a velocity that the tips of the blades of the fan travel at 16 feet per second, the height of the level of the water in the glass pipe above that in the tank will be exactly 4 feet. A scale, graduated on this principle, was placed alongside of the glass tube, and the speed read off by merely observing the position of the level of the water on the scale. This simple instrument has been at work during the last nine years, and has always given perfectly accurate results.

Mr. Robert Neville, who was a friend of Mr. Froude's, and was formerly a pupil of Messrs. Easton and Anderson, saw the instrument

a few months after it had been set to work, and asked Mr. Froude's and my permission to make a similar one, to apply to a steam yacht of which he was the owner.

As we had not patented the invention, we told him he could make as many as he liked. He accordingly made one for his yacht. Just after it was completed, he was engaged by Messrs. Easton and Anderson to look after some engineering work in London, and wishing to test the revolution indicator at once, brought it with him to London, and attached it to the shafting in the works, which were then occupied by Messrs. Easton and Anderson, at the Grove, Southwark, occupied formerly by Messrs. Ravenhill. I was told that the performance of this instrument was not satisfactory, but I never tested it myself. It differed from my instrument only in having curved blades, like those used in ordinary centrifugal pumps, instead of radial ones, and to this I attribute its inaccuracy, if it was inaccurate. I have mentioned this about Mr. Robert Neville's instrument merely because it was once stated, in certain quarters, that my instrument was a copy of Mr. Neville's, instead of the reverse being the case, and I know that Mr. Neville would readily enough admit it if asked.

Mr. Stroudley, the locomotive superintendent of the London, Brighton, and South Coast Railway, who, I believe, invented the instrument independently, has used this form of indicator on his locomotives with complete success, and it seems to me to be the simplest and best form of revolution indicator for use on shore, when the indication is only wanted close to the prime mover. It is unsuitable for sea use, as the oscillations of the ship would render the column of water unsteady. Admiral Ryder, while on a visit to Mr. Froude's works, noticed the instrument, and strongly urged me to try and adapt it for use on board ship, as it was very much wanted in the Navy. The conditions which he laid down were that it must be unaffected by the motion of the ship caused by waves, and it must, if possible, be able to indicate in several places, and those places to be at a distance from the prime mover. Thus it should at least be able to indicate on deck as well as in the engine-room, and it would be desirable that it should indicate in the conning tower, where the Commanding Officer is stationed in action, as well as on the bridge. In trying to comply with these conditions, it became evident that the glass pipe and the tank might be connected to the centrifugal pump by pipes and be raised to any height above it, and the same speed of pump would cause the same difference of level in the tank and pipe. In Fig. 1, these pipes are shown in dotted lines. The condition of indicating at a distance could thus be easily fulfilled by merely carrying pipes from the centrifugal pump to the place of indication. In order to fulfil the condition that the instrument was to be unaffected by the ship's motion, it became necessary to substitute for the water column a pressure gauge, in which the measurement is effected by bending a spring instead of by raising a weight, because then the two columns of water in the two pipes could be kept the same length, and would therefore balance one another, as far as any effect of ships' motion was concerned. It then became clear that a differential

pressure gauge, that is, one which would be actuated by the difference between the pressure in the two pipes, would be the right thing, because such a gauge would be independent of the absolute level of the water in the pipes, so that a gauge would indicate equally accurately whether it was attached high up or low down in the pipes, and consequently any number of similar gauges could be connected to the two pipes, and they would all indicate the same, for it is clear that the difference between the pressure in the two pipes is the same at all levels.

The indicator, therefore, took this form. A centrifugal pump, having one small pipe connected to its delivery and one to its centre; these two pipes were to be carried to all places where an indication of the speed of the engines was required, and at those places a differential pressure gauge was attached. At the highest point these two pipes terminated in a small tank, the purpose of which was to keep the pipes full by replenishing any loss there might be through leakage or evaporation. The pipe connected to the suction of the centrifugal pump was kept in permanent communication with the tank, the other pipe could be opened or closed as to its connection with the tank by a stopcock. A hand force-pump was attached to the pipes, so that, by opening the stopcock and working the hand-pump, a circulation of water from the tank and through the whole length of the pipes was established. This had the effect of clearing all air bubbles out of the pipes, and causing them to be completely filled with water. This was only necessary when the instrument was first set working; all the air being cleared out, no more could get in.

The construction of the differential pressure gauges required a good deal of experimenting before a form of gauge, which would be sufficiently frictionless and sensitive, could be constructed. Having got so far, I patented my improvements in 1874. I got an order to fit Her Majesty's ship "Turquoise," which was fitted out for sea at Sheerness, at the end of 1876, with my indicators. The instrument was constructed to indicate in the engine-room, the stoke-hole, and on the poop. The centrifugal pump was fixed in the shaft alley.

I was exceedingly fortunate in the "Torquoise" being my first ship, as through the priming of her boilers she made no less than thirteen trial trips, which gave me ample opportunity for remedying any defects in the details which might be brought out by practical working. Among other things, I substituted toothed wheels for driving the centrifugal pump, instead of the leather belt which I at first tried. By this and other improvements in details, by the end of the trials I had brought my instrument to a high state of efficiency, and the Admiralty authorities were so well pleased with it that they requested me to fit up the "Temeraire" with it, in which I was quite successful. This was in the summer of 1877. I have since fitted the following ships in Her Majesty's Navy with it, besides the "Turquoise" and "Temeraire:"—"Emerald," "Thunderer," "Nelson," "Northampton," "Iris," "Mercury," "Sultan," "Vesuvius," "Neptune," "Repulse," "Dreadnought," "Northumberland," "Devastation," "Cyclops," "Lightning," and six other torpedo-boats.

The German Admiralty have also adopted my indicator, and have had, or are having it fitted to the following ships: "Sachsen," "Preusien," "Friederic der Grosse," "Bayern," "Kronprinz," "Friederic Carl," and one torpedo-boat. The Germans are availing themselves of the facility with which my instrument can be made to indicate in several places at once to a greater extent than even our own Admiralty. For instance, in the "Sachsen" and "Bayern," there are six places in each ship where the speed of the engines is indicated, that is, three for each engine, for these ships have twin screws. The two engine-rooms are separated by water-tight bulkheads, and when in action, the water-tight doors being shut, there is no communication between them. They have, therefore, in each engine-room, besides the indicator belonging to that particular engine-room, an indicator which indicates the speed of the engine in the other engine-room, so that the engineer has before him the speed of both engines, so that the engines can be easily regulated to work together, even when there is no communication between the engine-rooms. The arrangement of apparatus now in use is shown in Fig. 2 on the diagram. The centrifugal pump is driven by a train of toothed wheels from the screw shaft, and is bolted against the side of the shaft alley, two pipes lead from it to the engine-room, where there is an indicating dial, the two pipes are then continued to the bridge and terminate in a stand which contains the indicating dial, and also the small tank for keeping the pipes full. Out of the side of the stand projects the handle of the force-pump for filling the pipes, while in the lower part of the stand is situated a store-tank for the liquid with which the pipes, gauges, and centrifugal pump are charged. This liquid consists of water mixed with one-sixteenth of its volume of glycerine, which does not freeze with any ordinary degree of cold. The chief feature of my indicator is the extreme facility with which it can be made to indicate in many different places. When once you have got your centrifugal pump fixed, you have nothing to do but carry two small copper pipes about the ship to all the places where you want an indication, a job which really need cost little more than a bit of domestic gasfitting. Every other revolution indicator that I ever saw requires a line of shafting to be carried from the engine-room to the places where it is to indicate. Those who are acquainted with the internal construction of modern ships of war know that in many parts they are a perfect labyrinth of water-tight bulkheads and flats, and that to carry a line of shafting about in these places is a difficult and expensive operation. Such a line of shafting has nevertheless been commonly used on ships of war between the engine-room and deck, merely to show whether the engines are going, and whether they are going ahead or astern. This shafting has to go round many corners, at every one of which a pair of bevelled wheels is required. It requires also numerous bearings, many of which have to be in places where it is very difficult to get at them to lubricate. The shafting often makes such a noise that it is ordered to be thrown out of gear while making a sea passage, and consequently any revolution indicator attached to it would be thrown out

of gear too. This system of shafting for indicating the direction of the engines' motion is so defective, that I have been led to contrive and patent an improved apparatus for the purpose, which has recently been fitted to H.M.S. "Northampton," with complete success. It consists of a small oscillating air-pump fixed in the shaft alley and driven off the screw shaft. This air-pump is so constructed, that when the engines are going ahead it exhausts air out of a small pipe to which it is connected, but when going astern it pumps air into the pipe. This small pipe, which is made of pewter, and is only $\frac{1}{8}$-inch in the bore, is carried either directly or by branches to all parts of the ship where an indication of the direction of the engines' motion is required. At each of these places an indicating dial is attached to the pipe, so constructed that if the air in the pipe is slightly below the atmospheric pressure, the pointer on the dial inclines to the left, and points to the word "ahead," and if the air in the pipe is above the atmospheric pressure, the pointer inclines to the right, and points to the word "astern." These dials are so sensitive that they respond instantly to the smallest motion of the engines. I have also lately patented an improved revolution indicator, in which the pressure impressed on the fluid by the centrifugal pump is communicated to the gauges by means of air, so that only one pipe is required instead of two. This improvement, besides saving the slight attention now necessary in keeping the pipes full of water, will also enable me to considerably reduce the cost of the instrument.

Mr. DEVERELL: May I ask if the instrument indicates with equal accuracy very high velocities as well as lower velocities.

Mr. TOWER: Exactly the same; in fact the high velocity is much easier to indicate accurately than the low velocity, because you have a much greater force. The fact is, the centrifugal force is as the square of the speed, so that with high velocities you get very much higher force; with twice the velocity you get four times the force, and consequently a much larger controlling force to overcome friction than at the low speeds. I have given a great deal of personal attention to the gauge, and as a rule the error is less than 1 per cent.

The CHAIRMAN: Can you from the upper deck indicate the required number of revolutions to the engine-room?

Mr. TOWER: No; that would be done by a revolution telegraph.

The CHAIRMAN: Orders as to the speed are passed down by word of mouth?

Mr. TOWER: I have often thought that might be done by one of Wheatstone's alphabetical telegraphs, if instead of letters round the dial you had figures to tell the number of revolutions. Some such arrangement is no doubt very much wanted.

The CHAIRMAN: I think Mr. Tower has explained everything so clearly that he has really left nothing for us to ask. I must say for myself I never heard of this indicator being adopted into the Service till to-day, as it has been out of my department. But in the years 1873–74, when I was Captain of the Steam Reserve at Plymouth, I was made to feel in a very practical way how much we wanted an arrangement of this sort to show the Officer conning what the engine was doing. I was taking the "Hotspur," one of the most easily steered ships in the Service, out of Plymouth Harbour, and the order was given to put the helm over a turn and a half to port, but as she did not answer the helm I had to go to the after end of the superstructure, where I saw by the indicator that one engine was going full speed ahead and the other was scarcely moving; and of course such a state of affairs would alter the whole condition of the steering power, and the ship instead of turning to starboard was going straight ahead. We got all the engineering talent in the Steam Reserve to try and see if they could get the indicator placed in front of the Officer, so that he

might know what his engines were about, but failed, as it involved too many turnings to the shafting and too many bevelled wheels. To-day I went into the engine department to ask about Mr. Tower's indicator; I found that he has fitted his indicator to several ships of the Service, and with one exception the report has been most favourable. The exception was the "Turquoise," which, after having it two years in use, found out that there was something wrong with it.

Lieutenant McQuhae, R.N.: Can the engineer regulate the speed of the engine with it?

Mr. Tower: The engineers in the engine-room can regulate the speed of the engine with it with the greatest accuracy. I have seen them just move the wheel of the regulator an inch, and you could see instantly the change of position of the pointer of the indicator.

Lieutenant McQuhae: The indicator we have now, although it will indicate in the end, is sometimes a little while before it begins to move.

Mr. Tower: It is very difficult to say how quick an indicator ought to be. If it is too quick it will be unsteady and will indicate the variations of the velocity of the engines in one revolution. For instance, the engine in making a complete revolution is going faster in one place than another, and you do not want that to be marked. My instrument indicates instantly any alteration of the speed, but at the same time it does not indicate the alteration in one revolution. With regard to the "Turquoise," I am not at all surprised to hear that after working two years it broke down. (The Chairman: It did not break down, but it was out of order.) It was the first one I fitted, and though during the trials of the ship I managed to make a great many alterations, yet, since then, in each successive ship I have made small improvements. When the "Turquoise" went to sea I was astonished to hear it worked at all, knowing how much trouble it gave me. (The Chairman: It worked for two years, and the naval Officers would make it work if they could.) I have always found the engineers of the Navy to be extremely intelligent: in fact, all the Officers have given their hearty co-operation in order to make the thing a success.

Mr. Deverell: Is the application of the indicator confined to ships of war?

Mr. Tower: The only other ship to which I have fitted it besides ships of war is the yacht "Wanderer," which was fitted up in the man-of-war style. I do not think it was really of much use to them, but they wanted to have all the latest improvements. The fact is it would not be of much use in the mercantile marine, though I hope by cheapening it, using the single pipe, that we may possibly get some of the mail companies to take it up. One great thing for which it is valuable in ships of war is in keeping station. Orders may be given to go at a certain speed, but slight alterations in the pressure of the steam make the engines vary a little and the ship gets out of station. But with this indicator, if the engines vary the least bit in speed the Officer on deck can see at once whether his orders are obeyed, and the effect of any alteration of speed upon the ship.

Lieutenant McQuhae: Is it possible to register the speed of the ship?

Mr. Tower: It has been tried a great many times. There have been modifications of what was called the Berthon log, the tube sticking out through the bottom of the ship and having its end stopped up. In the front was a small hole, and as it travelled along through the water the water was forced up in the tube. That, of course, could be made to act on pressure gauges, but the fact is, strange as it seems, you can never get exactly the same results. Dr. Siemens tried it on the "Faraday" and gave it up. Mr. Froude tried it on the "Iris," and although it was very useful for showing whether the ship altered in speed, yet they could never get any absolute indication of the ship's speed. It is a great pity, because a thing of that sort would be worth a dozen revolution indicators—to get an absolute reliable indication of the ship's speed, which you could see at a glance. At the same time, I am not at all sure that it would do away with the revolution indicator altogether, because in starting a ship it is some little time before her inertia is overcome. If, in starting a ship, the engineer was trying to regulate the ship's speed by a thing like the Berthon log, he might be a good deal bothered, because, first of all, he would move the regulator and would not see an immediate alteration of the ship's speed; so that it would not be such a good mode of regulating the speed of the engines as the revolution indicator.

Captain BURGESS: Can you reverse the action of your indicator if you are going astern?

Mr. TOWER: It makes no difference; the blades being radial and straight, it makes no difference whether you are going ahead or astern. If they were curved it might have a different effect. Mr. Neville made his indicator with curved blades; and I heard Mr. Ravenhill say it did not work accurately; that might have been owing to the curvature of the blades, because that would bring the friction of the water on the casing to bear. Surface friction is an extremely variable thing and would not give the same result two days running. There is no flow of water through my indicator, and the blades fit pretty nicely in the casing, and when the pump spins round it carries with it the whole body of water into the pump; it spins round like a cheese of water, and the centrifugal force acting outwards supports the column of water.

The CHAIRMAN: The Naval Service is one in which we are always learning. I have been 38 years in it, and I find myself ignorant of a great many things. I think in twin screw vessels this indicator would be found very useful. If you do not know that your twin screws are going at exactly the same speed you do not know what your steerage qualities are; because a ship with screws going at an unequal pace will not answer the helm so well as when they are going at the same pace. I am sure we return our hearty thanks to Mr. Tower for his valuable paper. He has supplied a want that most of us have felt.

Monday Evening, February 16, 1880.

VICE-ADMIRAL J. H. SELWYN, Member of Council, in the Chair.

SADLER'S DOUBLE-RUDDER AND MOVEABLE PROPELLER STEAM SHIP.

Read by Major J. M. MOODY, R.M.L.I.

MR. CHAIRMAN AND GENTLEMEN,—I take it that in support of every mechanical improvement that lays claim to the consideration of a body of gentlemen such as I have the honour to address, two things should be made evident:—First, that experience has shown improvement to be necessary; and, secondly, that it will be satisfactorily effected in the manner that may be proposed. It is impossible in the limits of an hour's lecture to deal exhaustively with the many problems of naval construction and steam propulsion that are opened out to consideration by the invention I shall have the pleasure of submitting to you, and I fear that from want of time many points will have to remain but lightly touched upon. Speaking, however, as I do, to an audience of practical men, many of whom have made this subject their special study, I assume that I may rely upon my audience to complete those outlines of thought which I shall only be able to glance at. Without further preface, therefore, I shall proceed to speak of some of those defects in modern steam ships which urgently call for remedy; and I shall afterwards explain to you how I propose that the remedy should be effected.

As you are aware, every large steam ship, as at present constructed, must be deep enough to give diameter to and secure the immersion of the propeller. A deep broad ship will not have speed with ordinary power; to secure tonnage she must therefore have length. But this extreme length results in a corresponding degree of weakness. Of this we have sufficient evidence in the almost daily records of the breaking of shafts, in the case of long, narrow ships; many of which ships are known to be in other structural respects of a superior class. Their great length allows them to bend and buckle about so much in bad weather and cross seas, that a tremendous strain is brought to bear upon the shaft: that being the only thing which cannot bend. To bear out my statement that the breaking of shafts in these long, narrow ships is due to their large ratio of length to beam, I may state that the breaking of a shaft at sea is almost unknown in the Navy;

and although a comparison cannot be made fairly between the merchant service and the whole of the Navy, still there are ships in the Navy, such as troop ships and store vessels, similar in build and doing similar duties to merchant ships, where the comparison would hold good. The chief and only essential point of difference between these ships and merchant ships is that they have much larger beam for their length. I do not recollect attention being called to this previously. I need only remind you that, when a steamer's shaft is broken she is entirely at the mercy of the waves, to impress upon you the importance of a preventive being afforded in this respect. There is no doubt that many vessels have foundered with all hands, from this cause alone. About a year ago the steam ship "City of Brussels," of the Inman Line, broke her shaft on a voyage from New York to Liverpool. Although she had more sailing power than the steam ships of any other line, she was thirty-eight days getting to port, and was given up for lost. The anxiety caused at the time was naturally great, as she had on board 300 passengers and a crew of 120. I could name a dozen other steam vessels which, within the last twelve months, have all been similarly disabled, and have just managed to reach port. In the black list at Lloyd's there are many vessels named that have foundered at sea with all hands, doubtless from this cause alone. The waste of valuable property and the expenses resulting from these accidents must be enormous, to say nothing of the sad loss of life.

These long steam ships are built on the narrowest margin of stability, and can scarcely make sail with the wind abeam. They are frequently to be seen coming into port with a list of from 15° to 20°, caused by their cargoes shifting, or by their bunkers being empty. Such ships are unsafe to navigate, as the compasses will not act when not corrected for heeling error, as is rarely the case, and are out sometimes as much as two points. But another great obstacle to the navigation of the long narrow steam ships is the vibration caused by the racing of the engines, combined with the effect of the broken water which rushes upon the rudder from the propeller. This causes the compass to fly about five or six points in rough weather, and makes it difficult to tell what course is being made. All commanders will bear me out when I say that, even in smooth water, with coals nearly consumed, the ship has so much vibration, caused by the propeller being near the surface, that the compasses are constantly shifting one or two points, and from this cause many a commander has had his certificate suspended, thus suffering through no fault of his own, but simply owing to the malconstruction of his ship. The interference with navigation from the structural defects I have named, is, I believe, the principal cause of the loss or injury of 90 per cent. of the steamers that are run ashore. Again, vessels of this kind are such bad sea-boats that frequently, in dirty weather, water gets down on the stoke-hole floors, and—rolling, as the long narrow steamers always do—this water forces up the stoke-hole floor-plates, mixes with the coal, and dashes about from side to side. The firemen cannot be persuaded to remain below to get their legs broken, and consequently steam cannot be kept up. The fires soon go out, the steamer becomes

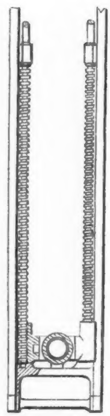
unmanageable, and if she does not founder with all hands, which is oftentimes the case, she comes into port a perfect wreck, and with her cargo damaged. A recent instance of this is the screw steamer "El Dorado," belonging to the British India Steam Ship Company, which was overtaken by a gale of wind in the Bay of Biscay, and was saved, and brought into Plymouth, mainly by the energy of the captain and officers, and by the brave exertions of the male passengers. She is 390 feet long, by 39 feet beam, and the usual build for going through the Suez Canal.

But I may mention that a further drawback to deep ships is their bad steering qualities, and especially their inability to steer quickly out of the way of other vessels. A steam ship, say of 500 feet long, draws about 26 feet of water, and steams on an average 15 knots an hour, equal to one mile in four minutes. Going at such a speed on a dark night, or in hazy or foggy weather, she cannot see a vessel ahead more than half a mile off; she cannot be turned out of the way in two minutes; and a collision is inevitable. The case is the same when land or breakers are ahead.

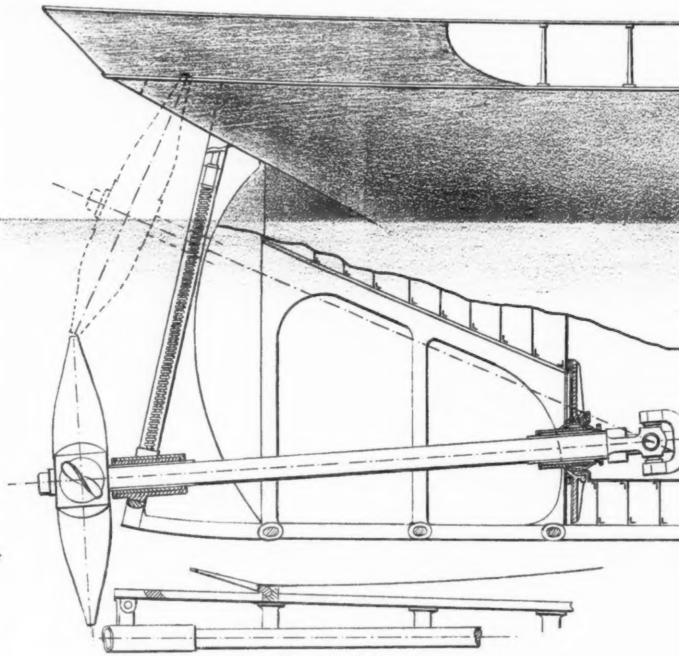
Such are a few of the disadvantages arising from the present construction of most of our steam ships: but, unfortunately, so little are these defects recognized in practice, that the length of steamers is being increased. It has now reached ten or eleven times their beam; and they often get strained so much, owing to their excessive length, that the owners are obliged to get them strengthened at a cost of from 10,000*l.* to 30,000*l.*, although, in the first instance, they are built far above Lloyd's rules. From what I have pointed out, it will be clearly seen that there is something radically wrong in the construction or model of these steam ships. To sum up, the defects to be overcome, are—excessive length, excessive draught of water, and insufficient beam.

To discover how, in the building of steamers, to avoid the extremes I have just named, I have devoted a great deal of thought and attention, and having had over twenty years' practical experience as a commander, having been in the India and Atlantic passenger trades, and having made myself acquainted with nearly all the losses of steamers which have occurred within the last nine or ten years, I have conceived and brought out the invention which with your kind attention, I will shortly endeavour to describe. First, however, I may mention, that about the year 1848, Captain Carpenter, R.N., invented and built a steamer with two rudders. His idea was to increase the strength of steamers about the stern-post, shaft, and stern-tube, which is well known to be the weakest part of all screw steam ships. He made a very wide stern-post, or two stern-posts, wide enough apart to admit the shaft between the two. The rudders were placed forward of the propeller, and hung on the dead-wood of the ship, close in before the stern-posts, one on each side. He was painfully disappointed when, on the trial trip, he found that the vessel would not steer. When the rudder was opened out to steer, the water rushed in behind it and upon the dead-wood of the ship, and caused a perfect block to steering. This goes to prove that, in order

SADLER'S PATENT LOWERING PROPELLER.



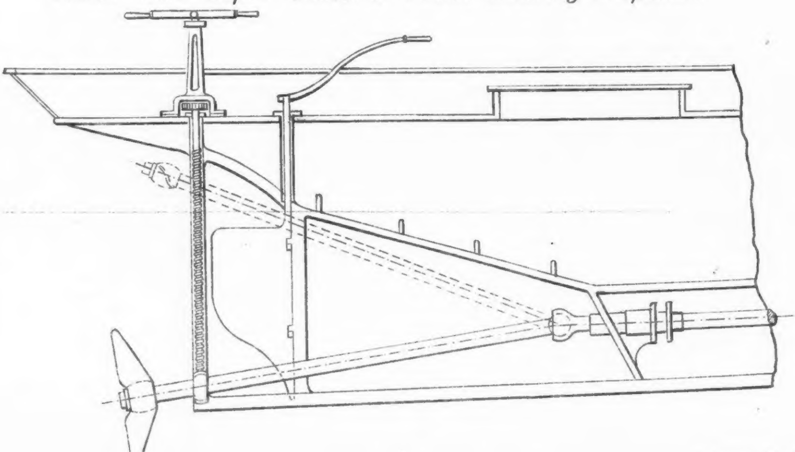
Elevation of Stern-posts and Lifting Gear.



Half Plan of Keel.

STERN OF STEAM YACHT "AHA".

Fitted with Captn Sadler's Patent Lowering Propeller.



Harrison & Sons Lith. St Martins

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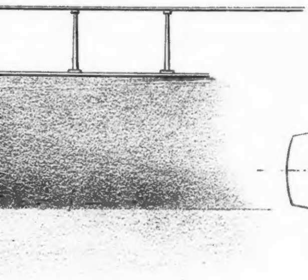
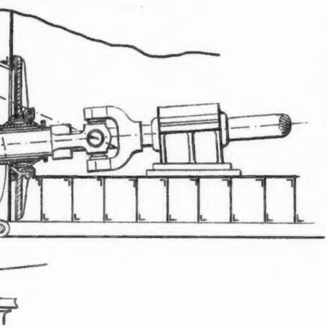
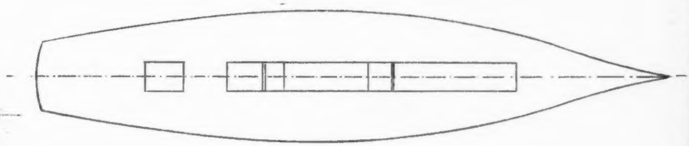


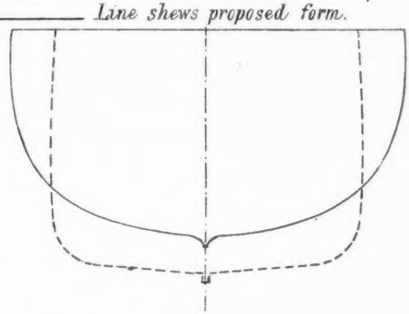


DECK PLAN. S.Y. "AHA".



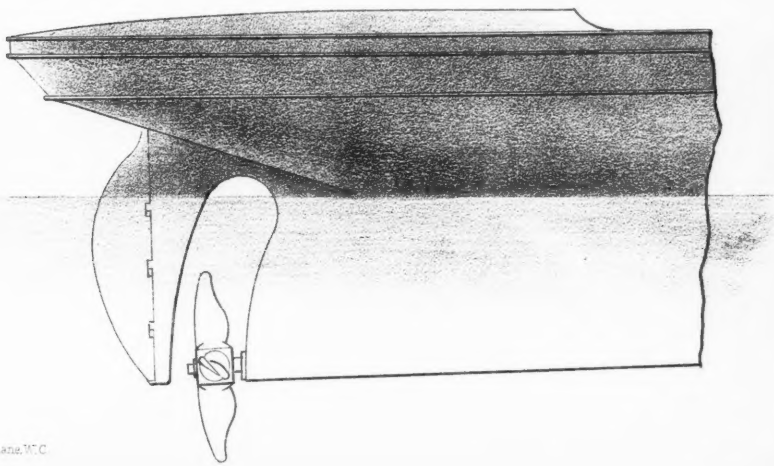
- - - - - - Line shews usual form of Midship Section.

———— Line shews proposed form.



STERN OF S.S. "BRITTANIC"

Fitted with Harland's Patent Lowering Propeller.



Sons, Lith. St Martins Lane, W.C.

to secure perfect steering in a ship, it is necessary that the water should pass with equal velocity on both sides of the rudder, and that the velocity must be equal to the speed of the ship.

It will, doubtless, be in the recollection of gentlemen present that, about four years ago, Messrs. Harland and Wolff, the celebrated shipbuilders of Belfast, invented a lifting and lowering propeller, and applied it to the White Star steam ship "Britannic." Everything in connection with the propeller-shaft and universal joint was a success; but, in consequence of the rudder being abaft the propeller, the rudder and rudder-post having no support from the keel nor anywhere above 25 or 26 feet from the keel, the action of the water from the propeller and the rolling of the ship caused great vibration on the rudder, and thus on the whole ship, and they were obliged to abandon this particular plan for ships of this size. I watched the progress of Messrs. Harland and Wolff's invention, because I was of opinion that anyone who should construct a ship with the propeller low down in the water, so as to prevent the racing of the engines at sea, would accomplish a most desirable object. For this reason, I very much regretted the failure of Messrs. Harland and Wolff's arrangement to meet a want so generally felt, and which has been attempted to be met in various ways; and being still of opinion that some such scheme was practicable, I continued to give the matter my serious thought and attention. The result is the invention of which I will now give a brief description.

The rudders, as the model and diagrams show, are hinged on the rudder-posts in the usual way, with gudgeons and pintles. Both rudders are in use at the same time, which gives double steering power to the ship. The lower after dead-wood is taken away, which enables the vessel to steer much more readily—going both ahead and astern—and at the same time admits solid water to the rudders and propeller. This also allows the propeller to be removed from the deadwood and stern; a point which the late Mr. Froude strongly recommended, but which it is impossible to adopt in the present construction of steamers. The after end of the keel is 3, 4, or 5 feet wide, according to the size of the ship, narrowed in to its usual width at about 50 feet forward. The propeller is raised and lowered by two vertical screws resting on the keel, which can be worked by hand or steam. The after carrying-bearing block slides up and down the stern-posts in guides, or can be clamped round the stern posts. The journal-bearing block oscillates in this carrying-bearing block. The after bulkhead is behind the universal joint on the shaft, with sliding door (*water-tight*), and upon the shaft is an oscillating ball, moving in a socket attached to the door. The universal joint is completely boxed in, and kept dry.

Permit me now to put in a concise form the advantages of this invention. The reason why high powered ocean steamers have such deep draught is to obtain immersion of the propeller; the proportions of vessels fitted with my patent lowering propeller are not governed by this consideration. They can therefore be made to draw less water. Thus shallow bars and rivers which are not navigable by the large steamers

requiring a great draught for the immersion of their propellers, and harbours similar to that at New Orleans, which have hitherto been inaccessible to such steamers, will no longer be so. The draught of water being reduced to obtain an equal displacement, the beam would therefore be greater; but I should recommend even a greater proportionate increase of beam.

Vessels built on this principle will also possess greater strength and be safer and better sea-boats, because of the superior proportions of construction which the improvements referred to admit of. The carrying capacity will be increased, and that with very little increase in the first cost of construction; whilst the extra expenditure in the first instance will be more than balanced by the avoiding future expenses for strengthening, and also from the saving in wear and tear after passing through heavy weather. There will also be no sacrifice of speed. There will be no vibration of the ship for the following reasons :—First, because the propeller being so far below the body of the ship, it will work in undisturbed dense water; and, secondly, because the propeller will be removed behind and away from the rudders. On this point I may repeat that, as has already been said, the cause of a great amount of vibration with the present build of steam ships, is the rush of the water upon the rudder from the propeller. To such an extent is this the case that I have known many vessels having to dock, owing to the plates on the rudder being shaken off entirely from the result of this action. Thirdly, there will be no racing of the engines; because the semi-diameter of the propeller is below the keel and cannot be pitched out of the water. In addition to this advantage, there will be the greatest possible immunity from accidents to the engines, which are frequently caused by their racing.

But these are not the only merits of the invention. The economy of the motive power by providing against slip will be considerable, though economy will not be confined to this alone. The fact that the pressure of the water increases with the depth is well known, as demonstrated by the late Mr. Froude, who found by experiment that an immense additional power is required to drive the lower 5 or 6 feet of these large flat-bottomed deep ships through the denser water. This element of resistance has not been sufficiently borne in mind by the designers of steam ships. There are steamers in America trading between New York and Boston which displace as much water as the largest White Star boats. They are 370 feet long, 60 feet beam, draw 12 feet of water, will steam 20 knots an hour, and will burn 30 tons of coal less in the day than the White Star boats. This shows the power that can be obtained by shallow ships; and this desideratum will be secured by the invention I have explained to you. Again, in my improved steam ships, there will be no thwart-ship bunkers, the extra beam allowing sufficient room for all the coals in side bunkers alongside the engine and boilers. The thwart-ship bunkers when empty are well known to be the principal cause of the straining of the vessel. This straining, as will be readily seen, is caused by the irregularity of load which is unevenly distributed when the bunkers are empty. Its defect would not only be avoided, but the placing of the

coals in the side bunkers opposite the engines and boilers would be a great protection to the machinery and boilers of torpedo-boats while in action; and would enable the ordinary merchant steamer to comply with the Admiralty regulations. Steamers, too, could be constructed on this principle so as to admit of being shifted in port without ballast, and even of crossing the seas with little or no cargo excepting coals for the voyage out and home.

In case of any accident occurring to the machinery at sea, rendering steam as a motive power impracticable, the propeller can be raised out of the water; and steamers constructed with my improvements could then proceed very advantageously under sail; or, in the case of a steamer going long voyages, such as to Australia, when she got a fair wind, the propeller could be raised, and the vessel would go nearly as fast under sail as with steam, and save in each trip from 400*l.* to 500*l.* in fuel alone. This arrangement would be of great advantage to steam yachts. A propeller with two blades could be raised up under the stern, completely out of the water, the fires put out, the funnel lowered, and the yacht put under sail until steam was again required. In addition to these and other advantages accruing to the merchant service from the improvements I venture to bring forward, steamers will be vastly superior as passenger ships, inasmuch as the vibration, rolling, listing, and other discomforts which are now experienced in trans-Atlantic and similar voyages will be reduced to a minimum, and the greatest possible comfort secured.

Having described the advantages of a more general kind which result from this invention, I shall now briefly point out what I conceive will be its utility to men-of-war and torpedo-boats. The Officers of the Royal Navy present will, I feel sure, fully appreciate the advantages I shall name, and be able to judge of the applicability of the improvements Of late years, considerable attention has, I believe, been devoted by the Admiralty and their advisers to the problem of getting the rudder and the propeller deep enough to prevent shot from injuring them. This has been sought to be obtained by overhanging counters, &c., but I think my plan will be considered the most advantageous to secure these objects. In addition, strength, speed, and seaworthiness will be promoted, whilst in the employment of large steamers of the Mercantile Marine as cruizers (as lately when a war appeared imminent was wisely determined on by the Admiralty) it would be found highly advantageous if, with the addition to the beam, my invention were adopted, as it will be seen that a much steadier platform for the guns would be afforded by vessels constructed on this principle.

In submitting this invention to you, I am not arguing from mere theory, or even the deductions of ascertained rules alone, but I am fortified with the results of experiment, and those results fully justify most of the conclusions I have come to. Last August I built an iron screw steam yacht, 60 feet long, 12 feet beam, and 6 feet deep, for the purpose of experimenting upon this invention. She steams very fast; will make a complete circle in $1\frac{1}{2}$ minutes, going ahead; and, what no other steamer ever did before, she will steer well going

astern. Several scientific and nautical men have seen her tried on the Clyde, and have expressed their belief in the success of the invention. I took her to Larne, in Ireland, in October last, in rough weather, and found the compass to work as steadily as it would in a sailing vessel. The beating of the engine was the only thing to indicate that we were on board a steamer at all. The propeller caused no vibration, and in consequence of the rudders being before the propeller they were not affected by the broken water from it, and were quite as steady as the rudder in a sailing vessel. In fact, the vessel has more than realized all my expectations. Some people may say that on account of the propeller being abaft the rudders, a ship of this kind will not steer; but I assert she will not only do so, but will steer quicker than any vessel of her size afloat, as the water acting on the rudders will be solid, not being disturbed by the action of the propellers. This, in the case of a light ship, is especially important, because, if the propeller is not completely immersed, each blade carries with it large quantities of air, the water being thus arrested and not solid. A propeller, where the upper blade is only just below the surface of the water, has also a very great tendency to drag the vessel's stern to whichever side the descending blades are on, and it sometimes has more power than the rudder. But where the propeller is deeper down in the water, that is not the case.

It has been remarked on former occasions that where the propeller is just behind the rudder, it is not so well protected as when in front, but it will be seen by the model that my propeller has more protection than others, because of the wide stern-posts; should it foul at any time, it can be raised and cleared. And at all times in port, the propeller can be lifted out of the water, and kept there.

And now, gentlemen, before closing this paper, I will just add a few remarks as to the best model for steam ships, a study to which I have given much attention for many years. We have on record that there are, on an average, *1,000* good and able British seamen washed overboard *annually*, and this arises principally from the malformation of modern vessels. Such a state of things ought not to exist, and would not exist if ships and steamers were built with an equal regard for capacity, economy, speed, and steering qualities in conjunction with comfort and safety. If shipowners and shipbuilders would consult commanders and ask them to note and report the seagoing qualities of their ships, it would induce them to watch closely all the movements their ships make in a seaway, and to attend to all the motions of the waves, and thereby form a conception of the kind of shape a ship should be of so as to be safest in bad weather.

I am convinced,—judging from my own experience,—that no steam ship should be longer than seven times the length of her beam. If a steamer is 400 feet long, she should have a beam of about 56 feet.

If 300	feet long,	6	times	=50 feet beam.
If 200	,,	5	,,	=40 ,,
If 100	,,	4	,,	=25 ,,

The broadest part ought to be a little before the midships and

narrowed in towards the ends, as here shown in the diagram, which is a deck plan of my yacht. The extreme beam ought to be carried up to the deck or gunwale, which would prevent the ship from rolling and listing over under sail. But the flat bottom and no keel is the great cause of steamers rolling so heavily, and to prevent this all steamers should have a deep keel or, which would be better, a great rise of floor. No part of the lines of a ship should be flat, square, or hollow. If all vessels had their midship section as shown in the red line in the diagram instead of the usual form as shown in black, there would not be the loss of life and property which this country has yearly to deplore. There is no doubt that circular ships roll the least, and I am certain that flat-bottomed and wall-sided ships roll the most. The "Popoffka" circular ship built for the Russian Government rolls only 7°. English steamers sometimes roll 35°. A steamer 400 feet long, with 56 feet beam, and that breadth continued nearly her whole length, and having a round bottom with great rise of floor and deep keel, would not roll more than about 15°, and she would be quick in her movements. It is necessary, in order to have an easy as well as a safe ship at sea, that her sides should form an approximation of the segment of a semi-circle, in which case she would only fall into the seas gently, but the seas striking her would not have such a damaging effect upon her round sides as they have upon the flat-sided ships. Seamen of 20 or 30 years' experience will remember the good old East Indiamen, or the fine old round-sided frigates that went to sea for years and never lost a boat, bulwark, or man, and would never capsize in a gale of wind or squall. But now the modern ship or steamer scarcely gets through a gale of wind without doing some damage and hurting or losing a seaman or two. In fact, the finest merchant steam ships in the world are constructed at the present day to go *under* water and not over it, and for this purpose they are covered with iron 60 or 70 feet at the ends.

I have no hesitation in saying that the reason the prevailing model of ships has not been improved upon, so far as safety and seaworthiness are concerned, in the last forty years, is because vessels have been constructed almost solely after the ideas of shipowners, and shipbuilders or engineers and seamen have been insufficiently consulted. To show what can be accomplished in effecting an improvement, I may state that a short time ago the American Government offered a reward to anyone who should make a model of a steamer that would go up and down the Erie Canal without disturbing the water and washing away the banks. The result was that now they have steamboats trading in the canal without making any wash on the sides, and thus thousands of dollars that were spent annually in keeping the banks in repair, are saved. Why should not the British Government, whose duty it is to take an interest in shipping and in the lives of our seamen, follow this example, and offer a reward for a model of a steamer that would have a maximum of the qualifications I have named—speed, economy, capacity, and steering qualities with comfort and safety, merely stipulating the capacity of the model and the power of the boilers and engines? The machinery for all the models might be made by one firm, and each

competitor should make his model after his own idea. Each model would have to be accompanied by a written statement as to the maker's opinion of the advantages his steamer would have, and his general opinion of how steamers should be constructed. Moreover, each applicant should be an experienced seaman, and the decision should be given by the best nautical men in the kingdom. I am certain that an arrangement of this kind would result in great good, and it might be the means of improving the models of ships and steamers, and help to prevent the terrible loss of life and property. It will be in the recollection of some of my hearers, that about two years ago the Shipwrights' Company made a step somewhat in the direction I have suggested by offering prizes for designs for the improved construction of vessels. I unfortunately had no opportunity of attending the interesting exhibition that was held in the Fishmongers' Hall, and I never heard whether there was any prize offered for a vessel that would preserve our seamen's lives.

And now, Mr. Chairman and gentlemen, in conclusion, I have only to thank you for your attentive hearing of this paper, which, though perhaps in some respects lacking novelty, and as I fear, deficient in the embellishments of expression, at least reopens for discussion many of those problems of marine architecture which are of such great importance to the mercantile community. I trust that I have converted some few of you to a belief in the merits of my invention; but if this gratification should be denied me, I shall still feel amply repaid for my labours if, as the result of my suggestions and the discussion here or elsewhere to which I hope my paper will give rise, something practical may be done in remedying the evils which I have pointed out, and which sufficiently testify that our shipbuilding is still capable of vast improvement.

The CHAIRMAN: It is now my duty to invite discussion upon this paper, redolent of the sea as it is, written by a man who thoroughly understands what he was talking about.

Commander CURTIS: I think every seaman must fully concur in Captain Sadler's idea as to what a ship should be; that is to say, that the extreme length in a very long ship should not exceed seven times her beam—I would say five and a-half. Moreover, the extreme beam should be about where the chest-tree used to be in our men-of-war, and ships should be built with a sheer, and, as I have said before, in the shape of a spheroid. A vessel should be built to float on her side as well as on her bottom. The fact of the matter is, that there is really nothing to bring these vessels up, no bearings, and they have such narrow beam, and are so wall-sided, that the sea makes a clean sweep fore and aft. At a meeting the other day of the Association of Ship Constructors, a gentleman whom I will not name said we should improve our seamen and have apprentices. A man would have to be improved very much indeed to enable him to make an unseaworthy ship a seaworthy ship. How a man is to make a vessel wear without shipping a sea, or round her to, when she is about eleven times her beam, I cannot conceive. I think we should adopt the form of the old French ships, though the French ships were perhaps a little in excess.[1]

[1] It has occurred to me that shipbuilders build vessels of the objectionable U form, to get as much tonnage into them as possible, "if so," there must be something wrong in the laws for the measurements of tonnage, or inconsistent, when one hears of a vessel registering 2,000 tons, carrying nearer 3,000 tons. I submit the

The "Royal Albert" and the "Formidable" had as fine bottoms as ever were seen on ships, and the "Royal Albert," with only 500 horse-power, could steam 10 knots, whereas the "Conqueror," with 1,000 horse-power, would only steam 12 knots. She was a longer and narrower ship in proportion. I quite confirm in my humble opinion what Mr. Sadler says, that a ship should be circular in her midship section and fine towards the ends, and they should have something to bear them up on the side. More reserved buoyancy, so that they lift to the sea, instead of the sea making a clean breach over them, as over a half-tide rock—washing the men off their legs, and making a clean sweep of everything, and pouring down the saloons, hatchways, and engine-room. H.M.S. "Formidable," in 1842, in crossing the Bay of Biscay, under close-reefed main-topsail and reefed foresail, logged for an hour or more over 15 knots, showing ships of her proportion and form can be made to have speed.

Mr. Griffiths, C.E.: As far as my experience goes, there are some very good points in the paper, but others are quite valueless. Years ago there were several ships built which had the screws placed behind the rudder, and, so far as speed relative to power is concerned, I believe the results given by those ships have not been exceeded. The danger, however, was that when going slow they would not steer, and also in going into dock there was always the danger of catching the screws. From my experience, I believe ships are made radically wrong. They have made them fine at both ends for speed alone. As far as the after-end goes, there is no necessity for this. I have tried several experiments on models, as well as on full stern ships, and I believe it will come out exactly the same in all vessels, that if you place the screw a certain distance away from the forward edge of the screw frame, whether it is a full stern or a fine stern, you will get an increase of speed of from 15 to 18 per cent., or up to 20 per cent., with the same power and revolutions. I believe our old East Indiamen, and our old frigates, were finer sea-going models than anything that has hitherto been made. The reason for our ships being made so fine is this: that when the screw was first introduced, it was found that the full lines of the stern of the ship reduced the speed, consequently, shipbuilders took the notion that nothing but a fine line would answer the purpose for the screw, and they have carried that to excess. As to beam, I am quite certain they are thoroughly wrong in making ships so very narrow. They think of nothing but speed; they do not look at anything else. Now, with regard to steering, Mr. Penn had a ship called the "Elephant." I told him about this plan of mine, and he said he would move the screw close up against the after stern-post from its position in the middle of the frame. The ship steered splendidly after the alteration, it did away with vibration, and he got a better speed. This does not add a shilling to the cost of a ship. We shall very shortly know more about it, because there are three or four ships now in the Clyde nearly ready on this plan, having a screw frame about double the ordinary width, and placing the screw right against the after stern-post. In other cases they will have the screw frame the ordinary width, and merely make the run the same thickness as the stern-post, for about two-thirds of the diameter of the screw. There is another fallacy, I believe, viz., that it is supposed that the effective part of the screw is the lower part below the screw shaft. I find that above the screw shaft is the effective part of the screw. When the screw shows a negative slip, you will find the bottom part of the screw merely passes through without driving any water back at all to propel the ship, and the screw acts only on the eddy which follows the ship at the top of the disc, and causes considerable resistance to the ship.

The Chairman: I see some great authorities on naval architecture present, perhaps they may give us some light on the subject.

Mr. Merrifield: I cannot refuse to rise, in obedience to the Chairman's directions, but I must say that I speak with very great unwillingness on this subject,

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measurement should be in accordance to how much water the vessel displaces, "then "we may have" what sailors term something in the shape of a ship, and seaworthy, not a number of wall-sided, tapered-ended steam cargo barges—unseaworthy, coffins, deterring the youth of the nation from going to sea in a very great measure.—J. D. C., Feb. 1880.

because I came here without any previous study, and what I have heard has not altogether prepossessed me in favour of the invention. There are two things, no doubt, valuable in principle. One of these is to keep the propeller as low in the water as possible, and the second is to keep the propeller as far aft as possible. I am afraid I cannot say very much in favour of the details with which they are carried out. Several of the principles laid down as principles of screw propulsion are such that I cannot give my assent to. The supposition that two rudders will steer with double the available power of one is assuredly not a proposition that can be considered at all axiomatic; and I certainly must say the same as to the large open spaces which you see allowed for in the diagram. I fell into the same mistake myself, years ago, and was corrected by those who knew better; but there seems very good reason to believe that this would seriously interfere with the steering, and I am not at all sure, also, that it is possible to design any sort of frame at all resembling that without meeting with a very great amount of resistance to forward propulsion, and also a considerable amount of weakness in the frame, for another thing, and that would introduce other sources of mischief. I am unwilling, when an invention of this kind is brought forward, to say all that I can against it, but I could not mention a point or two in praise without in fairness also mentioning objections to it. The paper consists of two parts: one, a description of the difficulty of the modern methods of propulsion, or rather of placing propellers, and the remedy for it by this invention; and, secondly, of a general disquisition on what the propellers and form of a ship ought to be. Now, to that point I think it is quite sufficient to say I cannot assent in any form. I can hardly be expected to go into the details. We have evidently before us an Officer of the old school, accustomed to handle the old form of East Indiamen under sail, and taking, as a new profession, possibly rather late in life, to vessels of which he does not like the form. There are, no doubt, in our modern long vessels, considerable inconveniences, but it must be recollected in this matter that what we have to do is not to provide the most comfortable yacht that a seaman can handle, and place a little cargo in her, but we have to design a beast of burden that will profitably, and at the same time without undue danger, carry our commerce, with profit to the freighter, safely across the seas. They have their inconveniences, but I cannot assent to such a wholesale condemnation of them in favour of the old-fashioned East India ships. You must recollect it is a mistake to suppose that those ships always escaped danger from foundering, for those who know the history of the East Indiamen and of the Royal Navy know that they had terrible losses, both in the Bay of Biscay and in the Channel, from sheer stress of weather—the very ships that we have heard so much praised.

Captain LONG, R.N.: I should like to say a word on the second division into which Mr. Merrifield has divided this paper. We have heard our merchant ships condemned in a wholesale fashion, but, for my part, having been at anchor at Bombay and other places when our modern steamers have been leaving port, I am sure no one can see them go out of harbour without thinking that they are sometimes very much overladen, and no doubt when we hear of these terrible accidents at sea, it is highly probable that the real fault lies in the way in which they are laden, and not in the way in which they were built. You may take the finest vessel in the world, and if you load her down until she cannot live, of course she is helpless. Another very important matter for this country is the professional standing of the captains of merchant ships. I know what these gentlemen think, and I have often talked to them, and I am unfortunately aware that their opinions have not that weight with their employers which they ought to have. I think that is a point which it is one's duty to notice, so that the attention of the country may be called to it, for there can be no safety when a profession cannot speak its mind as it ought to do.

The CHAIRMAN: There are certain points of mechanical construction here on which Mr. White could give us some very useful information. There are points about the peculiarity of the whole arrangement of lifting and lowering the propeller, and the constructive part, on which it would be very interesting to hear him.

Mr. WHITE, Assistant Constructor of the Navy: I did not propose to say anything on this paper. Through the kindness of Major Moody, I have had the opportunity of looking at the drawings and models pretty carefully. I will not

attempt to explain the mechanical details which the inventor would carry out, or to give any opinion upon them; if Admiral Selwyn will excuse me from doing so, I will simply say this: judging from the proportions which are common to ships-of-war, I can quite understand that a gentleman like Captain Long might be inclined to suppose a vessel in the merchant service to be overladen when she is not. In ships of the Royal Navy, the load draught is rarely more than one half the beam, whereas, in merchant ships (not quite for the reason which Major Moody has given on Captain Sadler's authority) the fully-laden draught often equals two-thirds the beam. Let it be considered for one moment what an enormous weight of coal must be carried when a ship starts on a voyage, say to Australia, or to the Pacific, in order that she may steam that distance. I believe I am right in saying some of these Australian ships carry about 3,000 tons of coal in their bunkers. Now, build such a ship as you like, she must lighten enormously during the voyage. Of course that lightening is provided against somewhat by the use of water-ballast; but she must lighten considerably. I am not disposed to think, because such a ship is at starting loaded down to two-thirds of her beam, that she, therefore, becomes unsafe, although it entirely departs from the precedents of ships-of-war. The ships of the Navy are altogether different. In the merchant service the weights—the cargo, coal, and so on—are placed low down, and there is consequently a very low position of the centre of gravity in relation to the total depth of the ship. Whereas, in men-of-war, the armament, armour, &c., are placed high up, and there is a very high position of the centre of gravity of the ship. So that, what might seem deep and dangerous lading in the merchant service may, as a matter of fact, be nothing of the kind. I do not think deep draught is adopted in the merchant ships for the sake of immersing the propeller; but if it were desirable to keep a shallow draught for the purpose of passing over a bar, or to fulfil any special condition of service, I think there is another well-tried method now in use which might be adopted in merchant ships, namely, the use of twin screws. I know, in the merchant service, there is a great prejudice against twin screws, because of the risks when ships are going in and out of dock, and are otherwise exposed to damage the propellers; but I can quite believe that some means might be devised for protecting twin screws; in fact, such means have been devised and tried. Looking at the whole question, I am of opinion that if limitation of draught is a desirable feature, such a limitation can be secured with no less efficient propulsion by using twin screws instead of a hinged piece of shaft. There are several points in Captain Sadler's statements with which I cannot agree altogether. I will not attempt to enter into them in detail; but I must mention one fact. Captain Sadler has, no doubt unintentionally, misrepresented some of Mr. Froude's experiments. It is not correct to say that Mr. Froude has shown that increase of draught largely adds to the resistance. On the contrary, in some of the very last conversations I had with Mr. Froude, before he left England to go on that voyage during which he died, he told me most distinctly (and I know it independently), that if there are two forms of mid-ship sections, one a broad shallow one, the other a deep narrow one, that, other things being equal, that which is deep and narrow will experience the less resistance. I am sure Major Moody will excuse my correcting that part of the paper. It is just as well that a statement of that kind should not pass uncontradicted. I think we are in the unfortunate position of having here a question of propulsion which could very well be discussed on its own merits, associated with other remarks on the general seaworthiness of merchant ships: on questions of form, as affecting the resistance and of propulsion and steering, which really do not belong to it. I am sure of this, that Mr. Merrifield is right in saying that two rudders, placed as these are, could not by any possibility give double steering effect. In the French service they use double-bladed rudders largely, and do not expect to get anything like double the steering effect from twice the area when two-bladed rudders are placed in that position.

The CHAIRMAN: I am sorry that there are not more seamen present who are disposed to enter into the subject on behalf of their fellow seamen, as I do not think there is any doubt, whatever the status may be of these gentlemen who command these very large steam ships, the Navy at least regards them with the strongest feeling of friendship as brother seamen. As we have had rather a strong opinion

expressed against some of Captain Sadler's statements, I should like to draw attention to some points in which he is undoubtedly right, and the principal point has been touched by one or two speakers. We have to build vessels which will do what the public ask them to do, irrespective of the fact that they are not as seaworthy, that they are not as pleasant, and that they are not such vessels as seamen would desire; but they do go at great speed. There is no doubt that the object which has been steadily kept in view by naval architects—that of triumphing over the last new ship built, in making the passage a few hours less between this country and the United States—has governed, in very great measure, the form of our steam ships. We have been obliged to resort to greater and greater length, not with any view of immersing the screw, but in order to gain a measure of that lessened resistance, which would be fully accomplished if we were able to set a board on edge in the water and drive it in that way. We are luckily limited in that direction; and I think we have attained to probably the utmost limit to which naval architects will be disposed to go, unless we get some new aid from the proportions and use of thinner and better metal. But there is one thing we can attain without sacrificing any of the speed, which is the naval architect's object, and which we seamen can fitly tell them of since they do not, unfortunately, go to sea in their own ships. I wish they did more often. When a steamer is built to be driven at high speeds through a disturbed ocean, not smooth water as is seen about the Channel generally, there is a point to be recollected in her behaviour at sea which influences also her speed, but which is very little attended to; that is, that if you choose to build a vessel as sharp in the beam above water as below, you will inevitably have her plunging into the sea and going under water instead of over it directly she gets into heavy seas. She will then need to have what is called a turtle back—an iron deck passing over a great portion of the bow to prevent the sea rushing along the deck. In the "Chimborazo," the other day, description was fully given of the ship's behaviour at sea. She simply takes in the sea over the bows and sends it out over the stern, washing away everything fore and aft in its passage. Occasionally there comes a time when she has to meet some extraordinary seas. I am not a believer in gigantic seas; there are no very abnormal seas in the middle of a gale of wind. There is what we call the ninth and the third wave that sometimes makes an accumulation, but nothing of the kind occurs sufficient to produce an abnormal effect on a large ship. What happens is this: the ship is wall-sided; she does not immerse any much greater proportion of buoyancy because of the advancing wave, and therefore does not rise quickly. Under those conditions the wave comes on with tremendous force right over the bulwarks, and sweeps everything away. In the case of the "Chimborazo" it was luckily only sheep, but it might just as well have been smokers, and then we should have had a very heavy outcry from the passengers against those who build such ships. There are things which may be done if naval architects would listen a little to seamen. I do not say that they should give way to prejudices, or to old-world ideas as to what was beautiful when we were content to go 10 knots; but I do say there are a great many points in which either they should listen to seamen, or they should consent to pass the very early years of their life at sea in order to get acquainted with the ocean for which they build ships. With regard to the arrangement of the screw here, I think we ought to derive some encouragement from the fact that so eminent a firm of shipbuilders as Messrs. Wolff and Harland did exactly the same thing, and only failed because they had left undone that which I think most shipbuilders, and probably they also, would have desired to see done. They did not provide for any support to the lower end of the stern-post, and got enormous vibration in consequence. Here there is some such support: whether it is a perfectly adequate support or not I should say can only be a matter of experience. I had originally, I confess, rather an objection to the universal joint. I considered that there must be a considerable friction and loss of power, and also from the indirect thrust of the shaft; but I should be quite reconciled to that loss, and quite prepared to support the arrangement in spite of it, if the screw can by its means be always kept from pitching out of water; for the most serious strains on the frame of the ship, the most serious losses of power, and most serious dangers to the ship occur from the sudden transition between whizzing the screw round in the air in spite of all the governors that have been invented, and

then suddenly plunging into the water: for that is the condition of a long steam ship of this kind—that she very often pitches her heel or bow clean out of the water. If that can be done even in a measure—though I do not think it can always be done in every sea by any means—I think a very great boon will have been conferred not alone on the owners and officers of steam ships, but also on the passengers, who hate nothing so much as the vibration of the screw, unless it be the motion of the vessel from beginning to end. If the screw can by that means also be got out of the water readily, there would be another great advantage to be gained. In many of our ships, the screw is not strong enough to stand the strain put upon it, and is constantly breaking its fans: and if we could raise the screw out of the water at sea, there ought to be no difficulty in shipping another screw. There have been serious losses to owners and delay to passengers occurring from that cause, and it is very desirable that it should not recur. While I was among the early advocates of the screw *versus* the paddle, I have long ago abandoned my early love for the screw in favour of the hydraulic propeller; but I am certain that if naval architects and engineers in modern ships will only turn their attention while screws last, as Mr. White has stated, to the twin screws, which I had the pleasure of naming twin screws; and if they will look at what Captain Symonds and Mr. Roberts did in the early advocacy of twin screws in providing means of getting them up and generally facilitating their use, they will cease to hate them, because they present some difficulties in getting into the docks and alongside of wharves. My experience of a screw steamer led me to believe that even with a single screw I could deal with any screw steamer much more readily in putting her alongside a wharf as soon as I knew the ship, than I could with a paddle. I never could trust a paddle-wheel at all, but with the screw I could do anything I pleased. I have taken a screw alongside of a wharf sideways, by alternately backing her and going ahead, using the screw in the proper way, and I am quite sure with twin screws that is very much more easily to be done, and also a steering power is conferred by the twin screw which does away with the great necessity for strong rudder action. I am disposed to believe that Mr. Merrifield and Mr. White are quite right in what they say about the action to be expected from these rudders; but the present action of rudders is by no means satisfactory, and if we could obtain only a small advance in the turning power of the rudder applied to these long ships, it would be a material benefit to everybody concerned. I think Captain Sadler deserves this great praise, that he has used his brains. He has been at sea all his life I have no doubt, and from what I hear, he has been very long in command of these "liners," and has learned to distinguish between what they can do and what they cannot do very accurately. He brings forward as an honest seaman his convictions on the subject. They may not always be well founded, but at least he has given that thought and attention to the matter which it is very much to be desired that every captain of every ship would give. If they were to bring their experience home, and put it candidly in whatever language before the English public, I am persuaded at last their experience would have its due weight, and it is in such Institutions as this, and on such occasions as this, that these experiences are most fitly brought forward, because they are subjected to the fire of discussion, and seamen get told where they are right, and I hope get praised a little for being right, and they are also very apt to get thoroughly well told when they are wrong.

Major Moody: I am sure if Captain Sadler were here he would be exceedingly gratified at the remarks made by the various speakers in reference to his invention; after what the Chairman has stated there remains very little for me to say; after his remarks, I do not regret the absence of a gentleman who has made this subject his special study, who, had he not been prevented by illness from being here to-night, would have made some remarks about this proposed steam ship from a naval architect's point of view, which would, perhaps, not have been so condemnatory as some of those which we have heard. As an outsider, I notice from the tone of the discussion that unfortunate differences of opinion between the sailor and the marine architect still prevail, although it is desirable they should go hand in hand. I see, as far as the sailors go, that they agree with Captain Sadler, but the marine architects totally disagree with him. Mr. Griffiths referred to the propellers being behind the rudders, and interfering with the navigation of vessels.

But I was told when at Hull, that in the Wilson Line, where propellers in this position are still used in some vessels, they get very good results indeed; steamers steering in a satisfactory manner, except, as Mr. Griffiths said, when they are going very slowly. But a captain of one of these steamers states that this disadvantage is only noticeable when they are steering about the dock. When they have any way at all they steer as well as could be wished. In a paper Mr. Griffiths read at this Institution about a year ago, he mentioned an experiment made by a Mr. Mackenzie, who moved the screw of his yacht I think 9½ inches further aft, and that gave him a speed of another knot an hour, and I think Mr. Griffiths remarked at the time, that if he could have moved the screw two feet further aft he would have got a speed of two knots an hour extra. It will be seen by Captain Sadler's model, that he moves his screw, I should think, a great deal more aft than Mr. Griffiths proposed, whilst it has the additional advantage of always working in unbroken water. I also believe that Mr. Froude warmly advocates the screw being moved aft, in fact, he found by experiment that the further aft it was the better. I think that this invention of Captain Sadler's brings it as far aft as it is almost possible to do. Mr. Griffiths also said that shipbuilders think of nothing but speed, but shipbuilders I believe, from what I hear, are governed entirely by their customers. Their customers say, "We want a ship to carry a certain amount of tonnage at a "certain price," and the shipbuilders try to give them the ship at the lowest possible price they can, and hence, I believe, they construct these long narrow ships that are undoubtedly at first much cheaper to build. But Captain Sadler has not confined himself to theory. He has tried his yacht, certainly only on a small scale, but still it is more than a model. He has tried it at sea in very rough weather, and he says it gives excellent results. His views are entitled to consideration. It is a mistake to consider that Captain Sadler is a seaman of the old school. He has been twenty years a Captain of a steam ship. I believes he occupies the position of Commodore of the State Line, a position that is given to the most experienced seaman, and the Officer who commands the largest ship in that particular line. The State Line is a very important line, and they make their passages very regularly, and I do not think we hear of many accidents happening to their vessels. There is no doubt the time must come when the country will call upon shipowners to provide a vessel—whatever their cargo is—that will carry seamen safely. How often do we see in the papers accounts of wrecks and casualties. Only a week or two ago I read in one paper of three vessels foundering. Mr. White speaks of modern steamers going to Australia, carrying 3,000 tons of coal; that is a large amount. At present there is no doubt that most of that coal is placed in thwart-ship bunkers. If it could be carried in fore and aft bunkers it would conduce greatly to the strength of ships, adding to their safety without diminishing their speed.[1] And with regard to twin screws, I believe, from what I can ascertain, the day is distant when they will be adopted by the Mercantile Marine. The difficulty is in getting vessels in and out of dock, and if they foul the result is very serious. I believe there is a great prejudice at present existing against twin screws. Captain Sadler, I believe, may not be quite accurate in saying he would get double steering capacity, but, as the Chairman very clearly pointed out, anything that will increase the steering capacity in any way will be, of course, an advantage. With regard to the proposed increased beam of ships, to which Captain Curtis referred, I think he agrees pretty well with Captain Sadler, only he would go still further in that direction, even to 5 or 5½. Many of our fastest war ships, the "Inconstant" and others, have 7; and some of the deep ships have 7 to 7½. The "Active" has 6¾, the "Warrior" 6¾, and the old "Mersey" had 5½. The old line-of-battle ships had 4. The "Active" with 6¾ got 14·9 knots at her trial trip, and the "Inconstant" with 6¾ got 16·4.

Captain CURTIS: The old "Formidable" got 15 knots under close-reefed topsails in the Bay of Biscay.

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[1] Had the "Chimborazo," on the Orient Line, been constructed on Sadler's improved principle, there is little doubt she would not have met with the recent disaster in which a portion of her crew were lost and the vessel obliged to return for a refit.

Major Moody: No doubt, as has been said, when these long narrow Atlantic steamers are in a moderate gale, not only will they not rise to a fore and aft sea, but often the waves strike them on the broadside and wash the men off the deck. It will be in the recollection of some of those present, that the second Officer of the "Cuba" and two men whilst on the bridge, two years ago, were all taken off in that way. In conclusion I would say that Captain Sadler will be very glad indeed to place his yacht, which is in good order ready for use, at the disposal of any scientific man who wishes to make any experiments with her, and thus satisfy himself as to the utility of the invention.

ADIE'S TELEMETER.[1]

By Mr. Patrick Adie.

Having been requested by the Committee of this Institution to give a description of my telemeter or distance-measurer, I do so, but with some diffidence. It is a subject on which I at one time bestowed a great deal of attention and time, and I shall be glad to open it up once more, and I shall hope to gain, if I cannot give, fresh information on what if a difficult, is still an important question.

Before going into the description of my telemeter, it would be well to say a few words on the methods which can be applied to the measurement of inaccessible distances generally.

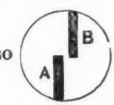
This is the more easily done since, so far as I am aware, there is but one method, viz., by angular parallax, because whether we use a long or a short base, a base beside the observer, or one at the object the distance of which is to be measured, it is still by means of the angular parallax that the measurement is to be made.

The above no doubt implies different ways of using the parallax. When the base is large we get much larger angles to operate with, but then there comes the difficulty that a series of operations and observations are wanted to perform the task, which involves time and the necessity for sufficient space. Now this, especially on board ship, is not always easy of attainment; in fact, except when the ship is quite stationary, is all but impossible.

The difficulty certainly does not apply to batteries at considerable elevation above the sea-level; there a sufficiently long base is attainable to give angles large enough to render us less dependent on great instrumental accuracy, and to which easy methods may and have been applied.

The difficulties therefore of using long bases, requiring in many cases to be measured for each observation, led me to turn my attention to the practicability of making use of a short portable base. My first efforts were directed to sextant type of reflection, working on the arc of excess of a portion of an enlarged sextant. I constructed one with great care of 18 inches diameter, but I found the great drawback was the difficulty of making a sufficiently delicate reading where you have to make the one image cover itself, as in the sextant, in which the image fills nearly the whole field of the telescope. I found in this instrument that ten seconds was about the limit of accuracy with most objects, another objection being also that in the Hadley reflection the angles are always half only of the real angle. To my surprise also, after having bestowed a good deal of labour on this, I found that exactly the same thing had been done by a Mr. Jonathan Cuthbertson, of Rotterdam, in 1792, in the most precise manner; an elaborate volume with description and tables being printed at the same time.

[1] Read at the Evening Meeting, on 16th February, 1880.

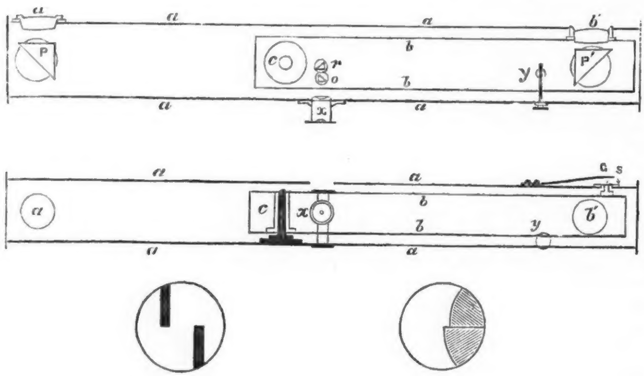
The next idea that occurred to me was to get rid of the half angles, to get more telescopic power, and to get such a reading as would enable me to approximate at least to two if not to one second. I was aware to a certain extent of the difficulties in accomplishing this. The first I soon got over, finding by a rough trial, that exactly as if I had two 18-inch telescopes, one at each end of say a 3-feet base, pointed at the same object, giving of course the true angle, so by bending the rays of these two telescopes at right angles, so as to make them come along the same tube from either end, and then bending them again at right angles in the middle of the tube, so as to make them fill each one half of the same eye-piece, I then got exactly the same effect as in the case of the two separate telescopes aforesaid, thus getting natural sized angles to work with. My next great gain which I found could be made use of by this arrangement was that instead of using the negative eye-piece, as in the sextant, in which case as before referred to, both images fill all the field and render a covering of the one by the other necessary to get coincidence of one object with itself, by using the postive eye-piece, the second reflections being nearly in its focus, I got rid of this difficulty and got clear images, each occupying half the field of the eye-piece and coming together sharp and clear, so that with good object-glasses and total reflecting prisms *one* and *two* seconds of space became appreciable; thus in reading, say a flag-staff, at a distance, the telemeter reading, is so 

, A and B, or one edge of each requiring to be brought together as one, in contradistinction to the sextant reading, which is so 

, A and B in this case requiring to cover each other exactly. And again by using telescopes in each case of rather longer focal length than half the base, much increased power is obtained, still preserving the great advantage possessed by the sextant, for an instrument to be used without rigid fixing being that of simultaneous observation. I shall now give a short description of the different parts of the instrument, referring by letters to the accompanying diagram. The upper figure represents a section of the instrument in plan and the lower the side view also in section.

a a is the outside telescope tube, *a′* the object-glass fixed to it, and *P* the prism or reflector which sends the rays up the tube *a a*; *b b* is an inner or second telescope tube extending a little over one-half the length of the outside tube; at one end *b′* the second object-glass is rigidly fixed to it; *P′*, a totally reflecting prism, bends the rays received by *b′*; the rays from *P* and those from *P′* meet, you may say, in the middle of the tube, those from *P* falling upon another reflector, *o*, also fixed to the outside tube, are turned at right angles into the eye-

piece *x*, and fill the lower half of it, and those from *P'* falling on another reflector at *r*, fixed to the inner tube, fill the upper half of the eye piece *x*; the other end of the tube *b b*, is connected by an axis at *c*,



which is fixed to the outer tube, thus giving a small motion in azimuth to the inner telescope, which is controlled and moved by a tangent screw at *y*. *s* is a scale attached to outer tube, reading by vernier *g*, fixed to the inner tube, the relative angle of inclination of the one telescope to the other, and so indicating the distance at which the two eyes or object-glasses are looking when both are directed to the same object; this angle, referred to the table on the instrument, gives the said distance in yards. I may mention that there is a small piece of tube across the upper side, near the eye-piece, which is very useful as a *finder*, the field of the telescope necessarily being small. The mode of observation need scarcely be recapitulated. It is desirable from time to time to check the index error if any exist; this should be done on a known distance, but it is also quite convenient to use the sun or moon, by preference the latter, as the sun's rays should not be allowed to shine long on one side, even with the protecting case, which, it may be observed, is separated by a space from the instrument to keep off unequal heating. In finding this state of the index, the circular edge or limb of the moon is treated exactly as we would a flag-staff, bringing the edge, seen in the upper prism, exactly into conjunction with the edge seen in the lower prism, for, it may be remarked, that it by no means needs straight lines to observe in order to measure the distance; I have found, for example, a horse's legs make a very good object of observation at 3,000 yards, or any distance according to the power of the instrument. The power of the only three sizes made may be stated as follows:—At a distance of 2,000 yards, which may be taken as an example, on a 3-feet instrument, an error of one second represents an error in distance of 18 yards, and an error of two seconds (fairly appreciable on the

larger sizes) represents an error of distance of twice that quantity, or 36 yards. This error will be doubled in the 18-feet instrument and halved in the 6-feet one. In the same way at half the distance, or 1,000 yards, the errors will be halved, and at twice, or 4,000 yards, doubled.

I am quite aware that this instrument is not yet what may be called a practical success, a few dozens have been made, but for some time I have given up the construction, because to be made well, they should be made in large quantities. Still, though I have waited patiently for some years, I have not yet seen any instrument coming nearer to all that is required of a quick, portable, single-observation instrument, making its reading on any object, independent of size or shape, and with a precision only limited by the quality of the instrument.

I am aware that this telemeter is like the sextant, delicate. We should not put the sextant into the hands of one who was ignorant of its use, either to observe with or generally to take care of. So with the telemeter, to make it available, it should be entrusted to the care of one man to measure with, and he should be responsible for its work, being trained regularly to the use of it, as riflemen are to the use of their weapons. Treated in this way I think that good results could be got out of it. The whole question is, can we read to one and two seconds with certainty if the instrument is well made? I think we can, and we know that astronomers, under enormously greater difficulties, and with not very much larger instruments, measure the distance of the fixed stars by their parallax, when in some cases the *angle subtended* is not more than three-tenths of a second. Therefore, an instrument of this construction, where the telescopic power is sufficient, the divided limb of long radius, having the great advantage of simultaneous observation, and where the readings can be repeated quickly, should be capable of being made to accomplish all that is required for purposes of gunnery.

Captain LONG, R.N.; We must all recognise the great ingenuity and labour that have been expended on this instrument. I must say, when I first saw it, I was so taken with it, that I went to Portsmouth and brought it under the notice of the leading Officers there. I tried the instrument on the ramparts, and though it was out of adjustment, I could ascertain the position of the flagstaff with considerable accuracy. My purpose in taking this matter up was that I was considerably struck with the imperfection of judgment in ramming manœuvres, and I wished to see if this instrument would afford any assistance. I had a chart and had the distance of the Ryde steamers coming in and out of Portsmouth, and I applied the instrument to see whether I could tell by it at what moment they reached a particular distance. I am bound to say in that I rather failed. I did get the distance within a considerable difference; I considered I was 100 yards out, and that in a matter of 500 yards. I then took the instrument on board the "Excellent," where I had Captain Herbert's assistance, and one or two of the Officers, and we tried to take the distance of the "Asia," and also of the "Nettle." In neither of those cases could we get the distance correctly, and that perhaps might have been owing to the index error which at great distances produced a very great effect. I am bound to say my impression on the whole was that the instrument, for naval Officers' purposes, was not likely, in its present state, to be of any very great value, although the principle of it seems very good, and in fact it seems the only manner in which an instrument could be made to give you those results but I could not help hoping in some form

or other it might be brought to be useful to us. There is no doubt it must be very useful to a surveyor on shore. It will give you very accurately distances across valleys, and would no doubt be very useful in many cases. I may, perhaps, mention that the late Admiral Sherard Osborn was very much impressed with the value of the instrument, and I believe ordered one.

Commander CURTIS: I think Admiral Ryder brought out a small telescope,[1] with wires inside it, so that knowing the height of a ship's mast, you could give the distance of the ship. But ships vary considerably in the height of their masts, and I do not think an instrument like that would give you the distance so accurately as this; because from what I can understand you have your own base line, and you have merely to look at the object. Now I should think if that instrument were correct, it is invaluable, because you have merely to look at the object, and to call out 3,000, 2,000, 1,000 or 200, as the case may be, to the Officer directing the guns. It is not left to the individual judgment of any one at all. It is much easier to do that than to look at your sextant. If I understand rightly, you have merely to look at the object, and at your index, and that gives you the distance.

Mr. ADIE: Just so.

Captain LONG: It is not sufficient to look at the object: the instrument must be held at right angles to the line of the object?

Mr. ADIE: Not necessarily.

The CHAIRMAN: Supposing I gave you a base 100 feet long, could you then enable us to ascertain distances on either the bow, the quarter, or the beam, with such an instrument (Mr. ADIE: I could) by considering the tube as a part of the structure of the ship? The instrument not being limited by portability may be carried in any size by the ship.

Mr. ADIE: I must have the instrument at right angles to the distance.

The CHAIRMAN: But that is done by turning the ship?

Mr. ADIE: Simply by turning the instrument. I can do that unless it goes the whole length of the ship. I have never contemplated anything beyond a six-foot instrument, because it is not necessary.

The CHAIRMAN: I ask this specially, because as an old surveying Officer I should have been very glad to have had an instrument that would have given the distance with any such facility. Our old-fashioned triangulation with the sextant is a very laborious operation carried out in boats as we had to do it, and anything of this kind might not only have uses in war, but also in peace, in facilitating surveys. I think if Mr. Adie would continue to theorize on the subject, he might enable us to do more than he has yet done by giving up the portability of the instrument and giving it us for this purpose on board ship.

Mr. ADIE: I may here say the greatest difficulty I have experienced with this instrument has been that of fixing glass and brass together. We have always used totally reflecting prisms in preference to metallic reflectors. No doubt we got far better reflection, but when I find that these instruments have stood half a dozen years, and yet, full of London smoke as they are, I can make a fairly good observation, I think, perhaps I have been wrong to confine myself to totally reflecting glass prisms instead of metallic reflectors which might have been fixed more safely. I want the instrument to stand a blow without being deranged; that has been the difficulty hitherto. I may state with respect to what Captain Long has said, he unfortunately coming unexpectedly when I was absent, did get an instrument with a large index error (it had been laid unused and out of my possession for some years), amounting to an error of $1\frac{1}{2}$ minutes, therefore the result at long distances could not be very correct, and at such distances rendering the observation useless, if not known and allowed for.

The CHAIRMAN: The meeting will, I am sure, return their thanks to Mr. Adie for his explanation of the instrument, and we hope that he will continue his studies upon it.

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[1] The instrument I referred to, is the stadiometer invented by G. H. Blackey, Master R.N. Length of tube in inches, height of mast in feet, gives distance in yards from the object.—J. D. C.

Monday Evening, March 15, 1880.

GENERAL SIR DANIEL LYSONS, K.C.B., Quartermaster-General, in the Chair.

"HELIOGRAPHY AND ARMY SIGNALLING GENERALLY."

By MAJOR A. S. WYNNE, 51st L. I.

IT is now nearly five years since a lecture on the heliograph or sun-telegraph was delivered in these rooms by Mr. Samuel Goode, who claimed for Mr. H. C. Mance, of the Government Persian Gulf Telegraph Department, the invention of this valuable instrument for signalling purposes. It was then explained that as early as the year 1869, Mr. Mance brought his heliograph to the notice of the Government of India. It was very favourably received, and subsequent reports testified to the success of experiments which had been tried to ranges of 50 miles without telescopes, one memorandum going so far as to state that with a 6 or 8-inch mirror, signals could be seen with the naked eye at a distance of 100 miles.

Since then the heliograph has fully realised the expectations of its supporters. The Government of India sanctioned its adoption in 1875, and each succeeding year its efficiency has been more and more generally recognised. It was used for the first time on active service, in India during the Jowaki-Affridi Expedition of 1877–78, and in the campaigns of the last two years in Afghanistan and Zululand it has been put to every possible test, with such satisfactory results that it must soon become an established addition to the Signalling Equipment of all armies.

It is not my purpose to advance the many instances in which sun-flashing has been employed advantageously elsewhere than on the north-western frontier of India. Most of us have read with what good effect it was eventually used at Ekowe and in the subsequent operations against Cetewayo and Seccocoeni; of its having been brought into play by the Spaniards across the Straits of Gibraltar; and by our own people in Australia and the West Indian Islands. We know that it forms part of the signalling equipment of the United States Forces, and as I am informed of other armies, all of whom will have points of interest to record.

My experience of the heliograph has been mainly acquired in a practical way on service. I have nothing to add to the theoretical knowledge of sun telegraphy; but as I had the honour and good fortune to be placed in superintendence of the signalling operations with the Peshawur Column of the Jowaki Expedition and of the Kuram Column during the first phase of the Afghan Campaign, I shall endeavour this evening to explain as far as possible the results obtained and the inferences to be drawn from the working

of the heliograph during those campaigns; and if any hint or suggestion I can give should prove of assistance to such of my brother Officers as may at any time be similarly placed, I shall not regret that my diffidence in appearing here has been overcome.

Origin of the Heliograph.

Reviewing rapidly the origin of the heliograph, the system of utilizing sun-light as a means of communication seems to have been known to the ancient Greeks and Romans. In the earlier part of this century a sun-flashing instrument called the heliostat was used in survey operations; and by its means triangles with sides exceeding 100 miles each were laid down in the Survey of the British Isles. The heliotrope, an improvement on the heliostat, has long been and is still very generally used; though somewhat cumbersome, its construction is simple, and it is provided with the means of horizontal and vertical adjustments. Then came the heliograph, which, like most inventions when once introduced and established, seems so simple, that the wonder is the other instruments did not sooner suggest the idea of utilising the sun as a signalling agent, by converting rays of light into active speaking signs, and adapting the flashes to a code.

While there will be something to learn from every new experience of the use of sun-flashing, it may be well to guard against many doubtful reports that are current of its application. Thus, while it is, no doubt, true that some primitive method of sun-flashing has long been employed by the North American Indians for war purposes, I have seen it stated that when some years ago, in the plains west of the Missouri River, 3,000 warriors of the Dahcotah tribe encountered an invading column of the United States Army, they not only adopted regular formations for attack and defence, but were manœuvred by means of a looking-glass which their chief held in his hand. The strong ray of reflected sun-light it is said was thrown on the ground, and moved in whichever direction the chief wished his force to take, they following the flash as it moved along the ground. At first sight this seems plausible enough, but to any one conversant with sun-signalling, the impracticability of the alleged method is at once apparent, for the flash from even a very large mirror, if projected on to the ground, becomes invisible at 100 or 200 yards distance, both to the signaller and those signalled to. Again, it is said that the Russians made use of sun-flashing for signalling purposes during the siege of Sebastopol; the following extract from a letter of the *Times* Correspondent having appeared on 11th July, 1855:—

"A long train of provisions came into Sebastopol to-day, and "the Mirror Telegraph, which works by flashes from a mound "over the Belbeck, was exceedingly busy all the forenoon;" it is singular, however, if such were the case, that they should have so forgotten the art as not to have employed it during the late war with the Turks, when on many occasions it would have been of such value. For instance, in Asia Minor a pre-arranged joint attack was to have been made on the Turkish position a few miles east

of Erzeroom by two columns marching along converging routes; one column was, however, delayed, and a separate instead of a combined attack resulted in the defeat of the Russian forces in detail, who were driven thence back to Kars. Had intercommunication been maintained by sun-flashing (and I have no doubt it was feasible) the march might have been so timed as to ensure a simultaneous assault. If the Russians had possessed a sun-flashing instrument, one might have expected to see it employed as a means of communication across the Danube and round Plevna, but so far as I can gather, heliographic signalling was not resorted to throughout the campaign. It is not improbable—but I throw it out merely as a suggestion—that the flashes came from some reflecting surface accidentally placed in line with the English camp. I have often seen effects not easily distinguishable at first from heliographic signals. For instance, during the three days General Roberts' force was encamped below the Afghan position at the head of the Kuram Valley, attention was attracted each morning at sunrise by flashes from the enemy's camp, and it was thought at first that they had a heliograph, but a careful scrutiny through a glass showed the light to be from the muzzle of a polished brass field gun. We may be sure that if the Russians had employed a signalling mirror they would not have exposed the signals to our observation, also that the fact would have been prominently mentioned in their official reports of the siege.

The introduction of the heliograph cannot fail to have a stimulating effect on Army signalling generally. Various methods of conveying intelligence to a distance by signals have been in vogue during the last few years in both the Army and Navy. So long ago as 1851, an "oc-"culting telegraph" was invented by the late Charles Babbage in which it is said the Duke of Wellington took much interest, and when the report came home during the Crimean War that the Russians were using a mirror telegraph which worked by flashes, the inventor addressed a letter to the *Times*, and suggested the idea of adapting sun-light to his system. Nothing seems, however, to have come of it, and until quite lately the Army has been contented, or rather discontented, with such apparatus as flags, semaphores, shutters, lamps, &c., &c. For, notwithstanding all the methods of communication which have from time to time been adopted (and the system and apparatus of Captain Colomb and Colonel Bolton are very admirable), and however useful they may have proved in their different spheres, it is undoubtedly a fact that Army signalling has languished, chiefly owing to the limited powers of the apparatus employed. Even that best of all signalling means, the field telegraph, is not without its defects, some of which I shall have occasion to allude to later on. Like everything else, sun signalling has serious shortcomings, still the heliograph has proved both in India and Africa a valuable addition to Army Signalling Equipment. Amongst the many advantages that may be fairly claimed for it are its great range, portability, the ease with which it can be established and communication maintained, and the rapidity of its working. If the ranges at which the operations during recent campaigns were conducted seem somewhat short, it must be re-

membered that the stations were established to suit the positions of the troops, and that experiments to test the limit of the range were not attempted. For instance, we read of twenty-four heliograph stations having been employed between Cabul and Jumrood, but it must not be inferred from this that when through-communication is required, so many points are necessary, for the whole distance of 180 miles from Cabul to Peshawur can without difficulty be accomplished through four intermediate stations, signalling between Cabul and the heights above Jellalabad, distant 75 miles, having been successfully carried on through a single station at Luttabund. It may be stated that under favourable conditions of sun and atmosphere, any two points visible to each other can be brought into communication.

Description of the Heliograph.

Several patterns and sizes of heliographs exist, in some of which there are departures from the original Mance instrument. The heliographs here to-night, one of which is from Roorkee, have been kindly lent by Mr. Goode. I am sorry I have none of those made more recently in India, for the regiments out there are exclusively equipped with instruments made in the Government workshops there, on the Mance principle. The Superintendent of the Canal Foundry has taken especial interest in their manufacture and been ready at all times to carry out suggestions for improvements in constructive details. However, without entering into slight differences of construction, I will describe the instrument now before you. It consists of a signalling mirror, reflector, sighting vane, and two tripod stands. The signalling mirror is so connected to the framework of the instrument that its inclination can be regulated horizontally or vertically. A tangent screw engaging the base plate enables the frame to be rotated and a telescopic rod clamped to the signalling key lever, and working by screw through a nut at the top of the mirror, effects the vertical adjustment. There is a small circular hole in the frame of the mirror and a corresponding unsilvered spot in the mirror itself, to enable an alignment with the distant station being taken when looking through from the back of the instrument.

The reflector is used when the sun is behind the operator, and should replace the sighting vane whenever the angle made by the sun, the heliograph, and the distant station exceeds 120°. The reflector has a sighting vane attached to its surface.

The sighting rod is so jointed that it can be readily moved into any position, it fits on to one of the stands, and has a silvered sighting plate, with a black spot in the centre called the sighting spot.

One tripod stand supports the signalling mirror and the other the reflector or sighting vane as required.

Sighting with Sun in front of Signaller.

The usual method of directing the flash to the required point has been to look through the mirror from the back and move the sighting plate until the sighting point is exactly in line. But a simpler and very accurate way is to " stand in front of the mirror and look-

"ing into it, bring the eye into such a position that the spot in the "centre of the mirror hides the reflection of the distant station. "Then move the sighting rod until the reflection of the sighting spot "comes into an exact line with the other two objects." The flash is then thrown on to the sighting vane and is rightly aligned when the dark shadow spot in its centre coincides with the spot on the vane. The shadow spot is occasioned by the centre of the mirror being unsilvered.

When the heliograph is adjusted, there is no chance of the alignment being disturbed, for however much the inclination of the mirror may be altered, its centre, being the axis on which it turns, remains stationary.

Sighting with the Sun behind the Signaller.

When it is necessary to use both mirrors, place the signalling mirror facing the sun, and the reflector inclining towards the distant station, stand in front of the heliograph and looking into the mirror so that the whole of the reflector can be seen reflected, move the latter horizontally or vertically, until the distant station, the spot on the reflector, and the unsilvered spot on the signalling mirror are in the same line.

Signalling.

The Morse code is so universally known it may be hardly necessary to remark that it consists of an arrangement of dashes and dots, or longs and shorts, to represent the letters of the alphabet, one of the former being equivalent in duration to three of the latter. The short flash from the heliograph is almost instantaneous, while the long is visible for an appreciable time. By an arrangement of these signs no letter involves more than four signs, whether dots or dashes.

According to the Army Signalling Regulations, no abbreviations are permitted; but I think this is a mistake, and cannot see why those authorized in telegraphy should not be adopted, or at all events those most commonly used.

The "General Answer," which consists of a succession of longs and shorts, kept up until the next word or group is commenced, should be abolished for the heliograph. The instruments receive more rough usage from it than from all the messages despatched. One flash kept up till the commencement of the next word is the best answer, signifying that the word or group is understood, and two short flashes for "not understood" signifying that the word is to be repeated. In the Regulations there is no sign laid down for "not understood," they provide that the word should be repeated if after a reasonable time elapses no answer is sent. And though theoretically this interval is limited to a pause equal to two longs, yet in practice a much greater lapse takes place, the sender hoping that the receiving station may be induced to take the word on reading the pretext of the message. This causes a serious loss of time which would be obviated by a "not "understood" signal. It is these unnecessarily long intervals between words which take up so much valuable time.

When the signalling key lever is depressed, it alters the inclination of the mirror according to the play allowed by an adjusting screw, and if the flash was before truly aligned on the distant observer, it would then be thrown over his head, and become invisible to him, but the pressure being removed the flash would return to its original position and reappear.

Heliographic signalling can be carried on by flashes or the obscuration of a fixed light. In the former case, *when the key is depressed* the centre of the flash is directed on to the sighting vane and is then seen by the distant station; when the pressure on the key is released the flash falls and disappears from view. In the latter case the centre of the flash is thrown on to the sighting spot and appears as a fixed light to the distant station until the key is depressed, when the flash is thrown upwards. In both instances the method of signalling is the same; long and short flashes, or long and short obscurations resulting from the periods of pressure applied to the signalling key, and in this way the letters of the alphabet according to the Morse code and other useful combinations can be signalled.

Flashing is the system in vogue in the army in India, and is more generally adopted than that of obscuration.

In signalling the left hand is kept on the tangent screw, and the right on the signalling key. The necessary adjustments to suit the (apparent) motion of the sun can thus be simultaneously made while in the act of signalling without any interruption or delay.

Advantages and Capabilities of the Heliograph.

It has been generally admitted throughout the Afghan campaign, that without heliographs no satisfactory communication could have been maintained. Until the operations developed and arrangements were made with the tribes, no dependence could be placed on the lines of field telegraph, the working of which was constantly rendered inoperative by malicious cutting. Taking the Khyber line for example, up to October, 1879, on a total distance of 108 miles of line, it was cut 98 times and 60 miles of working wire was carried away and never recovered. Considerably more damage has been since committed, and the recent operations at Cabul prove that when most needed the telegraph is almost sure to be cut. In December last, during the investment of Sherpur, the greater part of the line between Cabul and Gundamuck was entirely destroyed. But here the heliograph did good service, enabling the Sherpur garrison to hold communication with the solitary outpost at Luttabund, the connecting link with their supports, along the Khyber route, by which means General Roberts was able to assure the army in India, and the Government at home, of his security, and to issue important orders regarding reinforcements.

The service the heliograph has rendered in other ways during the campaign has been scarcely of less value, and the long lines of communication which by its use have been kept open have not only assisted the operations in the field, but spared cavalry and infantry much harassing duty in conveying messages from post to post.

Flags were quite useless as a rule to work over the distances which separated brigades and detachments; henceforth they will probably be confined to sunless days, for when the distance exceeds 4 or 5 miles a flag of such size must be used that working it for any length of time entails much physical labour and is tediously slow. Small flags for shorter distances may, in many cases, be of great service, but generally speaking as the distance diminishes it will be found quite as convenient if not as expeditious to despatch messages by mounted men or even foot messengers if the heliograph cannot be worked.

Amongst the many merits of the heliograph, the ease and certainty of attracting attention must not be overlooked. Every inch of country visible can be gradually searched by its means, and the positions of parties unknown before ascertained. If the tangent screw is pressed outwards, the mirror will turn freely right or left, and by loosening the screw which clamps the key-rod in its socket, the inclination of the mirror can be raised or lowered at pleasure.

The capture of the Peiwar Kotal on the 2nd December, 1878, was effected by two columns, one of which attacked in front, the other in flank. The configuration of the country did not admit of direct heliographic communication between them, but it was practicable by the establishment of an intermediate station. The detached signalling party, however, failed to reach the pre-arranged point, but by flashing all over the hill-side in the way I have indicated, their actual position was discovered, and interchange of messages effected.

During a surveying expedition made in January, 1879, from Khost into the Waziri Hills under Captain (now Major) Woodthorpe, R.E., I accompanied the party, and from one of the first hills where the surveying plane table was set up, Banu, a station 35 miles distant, and within the frontier of India, could just be seen lying at the foot of the hills on the banks of the Kuram River, and apparently not far from the Indus. A heliograph was directed on Banu, and although no previous intimation had been given, and there was only one Officer present at the station who possessed a heliograph, communication was soon opened; signalling had all along been maintained with the Head-Quarters at Khost, and messages were now passed between General Roberts and the Officer commanding the frontier. Banu being also in connection with the telegraph system of India, a message from the General was despatched to the Viceroy at Calcutta. It was afterwards found that a native sentry had noticed the flash from the hills and given intimation. From the same point, communication with Hasar Pir (distant 19 miles) was established, the attention of the signallers having been easily attracted.

From the Kandahar Field Force, it is reported that on the 12th December, 1878, a camp being discovered lying under the Kojak Range, distant 20 miles, a heliograph was laid on it, and a reply soon received. After marching 8 miles further on the same day, communication was opened with a camp 25 miles off, which turned out to be the head-quarters of General Biddulph's division.

Again, on the 29th May, 1879, Captain Straton, Superintendent of

Army Signalling with the Kuram Field Force, ascended the Sufed Koh—a range of mountains 15,000 feet above sea level, and separating the Kuram and Cabul valleys. Intimation had been sent to Jellalabad, warning the signallers to be on the alert, but when Captain Straton reached the top of the Agam Pass, he found Jellalabad obscured in a dust-storm which continued throughout the day; however, he proceeded to the Karaini Peak, close by, and carefully scanning the Cabul Valley through a telescope, discovered a camp which proved to be Gundamuck, distant about 30 miles. With Mance's 3-inch heliograph he attracted attention, and in fifteen minutes Generals Roberts and Browne, Commanding the Peshawur and Kuram Columns, were in communication.

More recently, with the Zaimusht Expedition under General Tytler, the force was divided into three columns which separated at Mundatoo under Colonels Gordon, Rogers, and Low. The "Pioneer" correspondent accompanying the force writes:—"The utility of having "this knowledge was well illustrated as we returned from Gondaleh. " . . We caught sight of distant high peaks overhanging the "camp at Mundatoo. Over these hills Colonels Gordon and Rogers "had taken their troops the day before. Suddenly from about "half-way down one of them flash, flash, flash came on to us. . . "Colonel Low called his signallers up, the message was from Colonel "Gordon to General Tytler informing him that both would reach "the head-quarter camp that night. Thus General Tytler knew the "position and whereabouts of all the troops out."

But perhaps one of the most prominent services rendered as yet by the heliograph was during Captain Straton's visit to Jellalabad in January last. On the 12th of that month, when at the signal station of Aliboghan, he found out that the Momunds had crossed the Cabul River; this intelligence he at once flashed off to Jellalabad, and that night a brigade started to intercept the enemy. During the following day, communication was successfully maintained between General Bright's head-quarters at Jellalabad, the brigade sent out, and a detachment of it, crowning the heights. At 1.15 P.M. (13th), Captain Straton saw about 1,500 men trying to cross the river, at such a point that, if they had succeeded, the brigade would have been cut off from Jellalabad, and the detachment severed from its main body. But intimation was at once signalled to all concerned, and by 3 P.M. a couple of guns sent out from Jellalabad were shelling the enemy with such good effect that they beat a hasty retreat.

I might quote many other instances of the kind, but those already given suffice to prove that with the heliograph no pre-arrangement as to time or place is, even up to such distances as 35 miles, absolutely necessary.

Signalling by moonlight with the heliograph has been practised during the last two years on service, and it is hoped that the results will soon be published. I have tried it on two different occasions; first in the Jowaki campaign between General Ross's standing camp and the Sargasha Ridge, and subsequently between Jutogh and Subathu, distant 12 miles. The signals were intelligible in each

instance, but the heliographs and telescopes were set up by day and remained in position till the moon rose, otherwise it is doubtful whether the alignment could have been hit off, unless signal fires had been used. At the time communication was established between the Cabul and Kuram Valleys, advantage was taken of a full moon, and a heliograph set on Kuram from the Agam Pass. The light was seen with the naked eye 12 miles off. Selinagraphing might often be very profitably employed; clear nights are the rule in India, and signalling by the reflection of a planet has been carried out for short distances.

Heliographs can also be used with artificial lights; during the investment of Sherpur, they were worked at night with the reflected light from lamps between the different faces of the works, and to the picquets on the adjacent heights where no telegraph existed. It may at first sight appear strange that a reflected light should be used instead of the direct light itself, but the ease and silence with which the movements of a mirror are made render the employment of the heliograph preferable to the extreme difficulty of preserving the alignment of a lamp, and the noise of its screen or shutter. The light being stationary, signalling proceeds uninterruptedly without any fresh adjustment being necessary. But with the regulation lamp issued to regiments in India, if the stations are any distance apart, it is very hard to keep the lamp held constantly in the exact direction which gives the receiving station most light, and if there is much work to be done, a man's arm gets stiff from holding it so long in the same position.

It has often been advanced as an argument against the adoption of the heliograph, that it is useless without the sun. The argument is unanswerable, but even the telegraph line is not proof against weather. With the Kuram Column field telegraphs were laid on posts without insulators; dust soon filled the notches cut in the posts, and when rain fell the electric current was greatly weakened or entirely lost. The ground line laid by the Field Train, from exposure to weather suffered in a like manner, for the gutta-percha covering being liable to crack, often on a rainy day the sounders in a telegraph office were as idle as the heliographs. But in a climate like India, it is surprising how few sunless days there are. Probably the proportion in a campaigning season would only be one in eight.

Clouds are of course a serious hindrance, and usually an effectual barrier to heliography, but to limited distances the flash from a mirror is capable of penetrating any ordinary haze, smoke, translucent clouds, or dust. In the Jowaki-Affridi campaign, the signal party at Peshawur were posted on the church tower; sometimes, owing to dust, haze, or smoke, the church became obscured to view, even through a telescope, and yet the signalling was uninterrupted. On the 19th January, 1878, the Peshawur signallers were called up from the Tor-Sapar heights, distance 24½ miles, and through-communication was then for the first time opened between the Peshawur and Kohat Valleys; yet on this occasion there was such a haze over Peshawur, that the outline of the church was hardly visible through telescopes.

The earliest reports speak to the penetrating power of the flash from

heliographs tried between Shaikh-Bodeen and Dehra Ismail Khan, distance 38 miles, although the weather was so hazy that the stations were barely visible.

Again, Lieutenant Savage, R.E., Superintendent Field Telegraphs with the Kandahar force, reports that on the 4th January, 1879, " Captain Bishop with General Palliser's advanced cavalry flashed us " up at 11 A.M. from about 14 miles ahead, and a message from " General Stewart was taken, which was sent on to him. Signalling " party rode on several miles, and on receipt of answer, opened com- " munication again and sent it; dust flying so thick that the hill on " which the distant party was stationed was nearly invisible, but their " flash was like a bright star through the dust."

Under such circumstances as these, no other visual signalling but that of sun-flashing would have availed.

Circumstances may often arise when sun-flashing would be very desirable, but no proper instruments are available. It may be as well therefore to mention that an impromptu apparatus, perfectly effective for temporary purposes, can be devised out of an ordinary shaving-glass in a few minutes. If two sighting points are aligned on the distant station, the glass can be directed truly and satisfactory signalling carried on by exposing and obscuring the flashes with a book or anything else at hand.

Selection of Signal Stations.

The selection of the best positions on which to establish signal stations in a strange country during active operations in the field, is perhaps more difficult than would at first appear, the difficulty increasing with the distances to which the lines of communication extend. When stations are far apart and the configuration of the country monotonous, the ready appreciation of the best points of observation requires an eye for country and aptitude for locality which cannot be expected from all signallers. An Officer should always be entrusted with this important duty; also when there is a press of work at an intermediate station, the presence of an Officer is essential to ensure the regular and rapid receipt and despatch of messages, for it often happens in such contingencies that signallers get disheartened when messages accumulate, and irregularities and delays are the consequence.

Sometimes it may be advisable to vary the stations, although still keeping up communication between the same signalling parties, for not infrequently the signal station is unavoidably some distance from camp, and more or less isolated and exposed. The fact of an enemy knowing that at a particular time and place he can rely upon finding a small body of men detached gives an opportunity for, and proves an incentive to, attack which might not be attempted under slightly altered circumstances.

If the country is hilly, and any difficulty is experienced in establishing communication for the first time between parties whose position is uncertain, delay might be prevented by the assistance of signal fires, heaping on damp straw or green brushwood in the daytime, so

that a column of smoke would ascend which could be discerned for miles, and clearly indicate the whereabouts of each. As before stated, there is little or no trouble in sweeping the flash from a mirror over all the country *within view*, but in the case, say of both parties being on low ground with hills between them,- the foregoing plan might be advantageously employed.

Some delay took place in establishing the stations at Hazar Pir and the Peiwar Kotal, because the signal party at the former did not ascend high enough. They distinguished the outline of the long spur extending from the Sufed Koh over which the road runs, and thought they saw the Peiwar Kotal Pass, but the block of hills about the Darwaza-Gai interfered and obstructed the flashes from both parties until a higher line clear of them was established; the distance between the two was 35 miles.

Training of Signallers.

Too much care cannot be devoted to the training of Army signallers, for it is when speed and accuracy can be relied upon that signalling proves so invaluable, and experience teaches that one is the accompaniment of the other. By the "Manual of Instruction in "Army Signalling," a speed of five words a minute is necessary for qualification with flags, but it is found that the signaller who averages over seven words a minute is more correct than another who does not attain to that standard. With the heliograph a much greater speed should be insisted upon, ten words should be the minimum allowed for qualification. From the earliest instruction signallers should be taught to work quickly, each letter being signalled at the uniform rate at which they will eventually be called upon to work; for beginners of course the pauses between letters can be regulated to suit the capacities of those under instruction, but if at first taught to signal and read slowly, they contract an imperfect style and disregard to *time* which is the essential of good signalling.

The training and practices should be made as interesting as possible, and all qualified signallers should have frequent opportunities of keeping up the knowledge they have acquired, periodical practice being necessary for a high state of efficiency. They should be exercised in detached parties sent out in different directions without any pre-arrangements, and instructed to find and open out communication with each other. During route marches, advance and rear guards should have signallers attached, whose duty it would be to avail themselves of every opportunity of communicating when advantages of ground offered. The men should be thoroughly conversant with the best kind of back-grounds, which differ materially for heliographs and flags; for instance, a sky-line is the best for a flag, but the worst for a mirror. Careful consideration in the selection of back-grounds will often save much time by avoiding the necessity of any subsequent alteration of the position taken up.

Staff of Signallers.

It would be almost impossible to lay down any hard-and-fast rule

regarding the numbers of signallers that should accompany an Army taking the field, so much would depend upon the nature of the country to be traversed both geographically and politically, and the disposition of the troops. In every instance the requirements would be subject to constant variation, and although 20 signallers might in some cases suffice for a force of 5,000, it is quite certain that the proportion this would give of four to a thousand would be inadequate. Roughly speaking, taking the numbers with the Khyber, Kuram, and Kandahar Columns during the first phase of the Afghan campaign, the proportion of signallers to fighting strength was as 1 to 250.

A memorandum from the Quartermaster - General's Office, dated Lahore, 11th December, 1878, states that " *all* the signallers are to be " made over to the Officer in charge of signalling, who will arrange for " their pay, rationing, discipline, carriage, camp equipage, &c.;" this memorandum was issued after the force had crossed the frontier, and it was found impracticable therefore to carry out the instructions in their entirety. Lieutenant Savage, R.E., Kandahar Column, reports: " with this force the signallers have seldom been detached altogether " from their regiments . . . . they are more comfortable than " when entirely detached."

Perhaps a compromise between the two would answer best. There might be a permanent staff consisting of specially selected expert signallers in the proportion of say 1 to 300 entirely under the signalling Officer. He, however, would be in possession of the names and qualifications of all the other certificated signallers with the force, so that at any time when extra work had to be done, signallers could be drawn from regiments and detachments on the spot, who without being removed from their companies, could, for the time, give their services, and receive their signalling pay according to the periods of employment. It is very desirable not to withdraw men from the fighting strength of regiments unnecessarily, and this would often be the case if a sufficient number of signallers to meet all contingencies were kept as a permanency on the signalling staff.

Pay of Signallers.

During the Afghan campaign, the Government of India sanctioned extra pay to signallers, at the rate of eight annas for non-commissioned officers, and six annas for privates, per working day. This was most desirable, for not only were they generally kept employed, but the wear and tear to clothing and boots greatly exceeded that of their comrades. If not actually at work, they always had to be at their posts, for the success of signalling operations depends upon the careful look-out kept so as to ensure a signal from any direction being promptly responded to. Formerly, then, it can hardly be wondered at that the position of a signaller was not much coveted, but now that they receive remuneration, a high standard of efficiency should be exacted before a man receives a certificate of qualification. The responsibility of their duties should be impressed on them, and the strictest observance to the regulations laid down for the conduct of a signal station should be enforced. None but really first-rate

signallers, and fairly educated men, should be entrusted with the charge of a station.

The heliograph does not yet form part of the signalling equipment of regiments at home or in the Colonies, and being of comparatively recent issue to those on the Indian Establishment, men are borne on the Signalling Rolls of their regiments irrespective of their knowledge of that instrument, and it happened when signallers were called for, some were sent to the front who had never been trained with the heliograph, and until they were taught their services were of little or no use. It is not a case of two heads being better than one, for one good signaller left entirely to himself will get through more work than half-a-dozen indifferent ones.

Mounted Signallers.

When troops are on the line of march mounted signallers should always be held in readiness and placed as circumstances may require, for in the event of any communication being necessary between, say the advanced and rear guards or flanking parties, by the time Infantry Signallers had opened communication and despatched whatever business there was, the column would have moved on and they would be unable to regain their places without much fatigue, whereas cavalry men could push from point to point with ease and rapidity. They might also be most advantageously employed when a signal station happened to be some distance from camp, for not only would the dismounted signallers be saved harassing marches to and fro, but communication would be opened earlier of a morning, which is a desideratum. The brightness of the sky and power of the sun in the forenoon should be utilized to the fullest extent, for in a climate like India, just double the amount of work can be got through in the morning as is possible in the evening. Generally speaking the sky becomes more or less cloudy after one o'clock, and stations bearing west appear surrounded with haze.

General Biddulph strongly advocates the employment of mounted signallers. With the Peshawur Valley Field Force signallers from a cavalry regiment accompanied all reconnaissances. From the 20th to 23rd March, 1879, they rode out to a height about four miles from Jellalabad and kept up communication between General Browne's head-quarters and General Tytler's force, which was destroying the towers of recalcitrant villagers in Maidanak. Again, on the 26th December last, a brigade marched from Cabul to Mir Butcha's forts in Kohistan, and by sending out a cavalry signalling post daily to the hills north of Sherpur communication was maintained with the brigade, although two ranges of hills separated them from the capital.

Screening Heliographs.

The work at a signal station is naturally subject to constant fluctuations, and it is when a number of messages pass along the line that the strictest superintendence becomes necessary, for if everything is not in good working order and discipline not enforced, the sun sets before perhaps half the messages have been despatched. Heliographic

signalling requires the greatest patience. This should be impressed on men under instruction, for they are certain to have their forbearance and tempers put to the test. Either the light fails at a critical moment—the reader at the opposite station requires constant repetitions—he, in his turn, does not give the most favourable flash to read by—and so on; it is astonishing how many interruptions *do* take place, but practised hands soon get accustomed to such vexations and learn the value of time. However, notwithstanding every forethought and supervision, the press of messages is sometimes too great for the ordinary single line of heliographs, and when this is the case and the instruments are available, they should be doubled. This was done when General Roberts visited the Peiwar Kotal in February, 1879; the telegraph line was only then laid as far as Habib Kila, so a couple of instruments were set up at each station, one for despatching, the other for receiving messages, and by this means just double the amount of business was transacted as would otherwise have been possible. To avoid confusion the heliograph despatching was screened from the party despatching from opposite station and *vice versâ;* the men reading at one station were not interrupted by seeing the answering flash of the party receiving at the other. A tree, rock, or the gable end of a hut became available to screen the instrument.

The flash from a heliograph is a reflection of the image of the sun and consequently has an angular diameter of 32′. The diameter of a disc of light increases with the distance from the mirror. At 107 yards the disc is one yard in diameter and theoretically should increase one yard in every 107, but practically it will be found to increase very much more. This proportion would give only about 66 yards for a range of four miles, but the flash has been seen at that distance for 100 yards on either side of the signal station. Thus it might be necessary, in the event of an enemy being likely to decipher the signals, to screen the flashes from his view, and as this requires a little nicety it should form part of the instruction of signallers. On the other hand the flash may have a discouraging effect on an enemy. It was generally considered by the Affridis that the heliograph was a mystic instrument by which homage was paid to the great Sun-God, his favour invoked, and the light of his countenance prayed for. This superstition was confirmed to their minds by the fact that snow, which usually falls in November, held off till February and extraordinarily fine weather prevailed, favouring the movements of troops and facilitating the collection of stores to an extent which under ordinary circumstances would have been impossible. And in December last when the Cabul force was temporarily shut up in the Sherpur cantonments, surrounded by the largest number of fighting men that have ever been assembled in those parts, heliographic communication took place between the garrison and Colonel Hudson's small force at Luttabund. The flash must have been seen by many of the tribesmen, warning them that the connecting links with the Khyber Division were still intact and that reinforcements would soon be pushed forward to put to flight Mahomed Jan and his followers.

In connection with the subject of screening flashes, it may be well

to mention that when three signal stations happen to be nearly in a straight line and are all at work, the terminal stations will possibly be much inconvenienced by observing the flashes from two mirrors. A case of this kind occurred in the Kuram Valley last year. The Peiwar Kotal signallers worked with Habib-Kila and Kuram, both of which, although 12 miles apart, had the same bearing. The Kuram signallers could see the sheen of the mirror working to Habib-Kila as well as the flash of that directed on them. This was rectified by screening the heliograph from the station for which the messages were not intended.

Signal Fires.

There can be no doubt that the hill tribes of the N. W. Frontier carry on communication by signal fires. These beacons can be seen for such vast distances that it is possible the revolt which took place at Herat the day following the massacre of the embassy at Cabul was pre-arranged and that the temporary cessation of British influence at the capital was by some preconcerted signal communicated across the hills.

It would be interesting to know if they have any particular code. Probably their signals are very limited and just arranged for the time being, still any system by which the simple intelligence "all's well" or the reverse can be communicated, is worthy of attention, and until a great improvement in the lamps in use with regiments takes place[1] signal fires might often be resorted to with advantage.

A curious case of night signalling was watched on the arrival of General Roberts in the Khost Valley in January, 1879. The Ameer's representative, Naib Akhram Khan, held the Matun Fort with levies which were not at first removed. The ex-Governor of Khost, with the usual treachery and dissimulation of his race, had assured the General that all was quiet and that the inhabitants were looking forward with joyful expectancy to the British Raj. During the first night a torch was carried round the ramparts presumably to acquaint Mongals and Khostwals that they still retained possession of the Fort, and flashes, as if a handful of gunpowder had been thrown on to a fire, were answered in a similar way from the hills. The events of the following day gave additional proof of the character for which the Afghan is so proverbial. No supplies had been furnished, and a cavalry reconnaissance drew the enemy, who were harboured in the surrounding villages. They sallied out on three sides of the camp, and as it afterwards transpired, looked upon the annihilation of the force and the general looting of the camp as a certainty. The tribes between the Khost and Kuram Valleys were ready to close the communications and actually seized a cavalry outpost at Yakoobi. It is needless to say that their schemes were frustrated.

Heliographic Chart of India.

It is probable that no perfect heliographic system could be

[1] Lieut. Whistler Smith, R.E., Superintendent Field Telegraph, reports that his experiments with Begbie's (C) pattern lamp were successful up to 25 miles.

established connecting the stations scattered over the plains of India, the country is so flat and the lower strata of the atmosphere as a rule so dense and murky, but there is no reason why stations within view of the hills might not be connected, by making use of carefully selected points in the hills as intermediary, stations in the plains invisible to each other might thus be brought into communication. This would especially be the case in the Punjab and parts of the N.W. frontier. Signals between Chakrata (in the hills) and Roorkee (in the plains) have been read with the naked eye, and as they are 60 miles apart it is not improbable that with the aid of good telescopes many of the principal military stations could be connected. When opportunity offers it might be as well perhaps to institute practical experiments and have a clearly defined scheme drawn up which would bring as many as possible of the more important points into communication, so that in the event of any interruption in the telegraph line, the alternative means could be resorted to without delay.

The " Heliostat."

In the "Army Signalling Manual" an instrument called the heliostat is described, which differs from the heliograph chiefly in this particular only, viz., that instead of making the appearances and disappearances by a slight alteration of the mirror they are effected by raising or lowering a shutter which exposes and hides the reflecting surface. It is evident that this is a slow and laborious process in comparison with the rapid and simple motion occasioned by the slight pressure of a signal key. The reason assigned for this modification of Mr. Mance's original instrument is that the action of the finger key disturbs the tripod, and alters the alignment. I can confidently say that during the whole time I have worked with the heliograph, and I have done so on every variety of ground, no such difficulty ever presented itself. If the instrument is properly set up, the alignment is easily made and as easily preserved, and the motion of the mirror either in signalling or adjusting does not interfere with it.

Conclusion.

It will be evident from what I have said that army signalling is likely to play a much more important part in warfare than has hitherto been the case. However old the use of mirrors may be for flashing, their employment for conveying verbal intelligence is of quite recent date. We hear nothing of heliograph messages in the American Civil War, the Prusso-Austrian, the Abyssinian, the Franco-German, or the Turko-Russian Campaigns, and we may perhaps accept this as sufficient proof that no such instrument was then in use. During the last two or three years, however, the heliograph has proved of such incalculable value that its importance cannot be overrated. The evidence brought forward this evening may perhaps induce my hearers to concur in the opinion that the subject is well deserving the serious attention of the authorities in order that the service may be provided with the best possible equipment, and army signallers encouraged to make themselves proficient in the art of heliography.

APPENDIX.

Notes on Construction of Signalling Apparatus.

A few remarks on the signalling apparatus and the component parts of heliographs may not be out of place.

Nearly all the instruments used in Afghanistan were of the regulation Roorkee pattern varying in details according to the date of issue. The mirrors ranged between $4\frac{1}{2}''$ and $5\frac{1}{2}''$ in diameter. Each column had in addition a 3" instrument supplied directly by Mr. Mance, and it was worked most successfully between the Peiwar Kotal and Ibrahimzai—distance 30 miles. The tripods were, however, too light to withstand wind and rough usage, but in accordance with recommendations made at the time, they have since been constructed more substantially with metal plates strengthening the joinings of the legs with the centre piece.

So many sizes and patterns have now been tested that it would be well if steps were taken to decide upon the most desirable. While undoubtedly the 5" heliograph is the best adapted for general use it would appear advisable that a proportion of 3" instruments weighing only about as many pounds should be available for reconnoitring parties and mounted signallers, and 8" or 10" for distant signalling. When the question has been carefully considered, great exactness should be observed in the manufacture of all the component parts so as to render them interchangeable. Some of the instruments in use with regiments in India were made at the Sappers and Miners Workshops, others at the Roorkee Canal Foundry, and the fact of the mirrors and various parts not being similar was often the cause of much inconvenience.

Sighting Arrangements.

When the heliograph was in its infancy, a sighting rod was set up about 10 yards in front of the instrument, and fitted with a metal stud which slid up or down until truly aligned with the distant station. In communicating, the flash was kept playing on the stud. This sighting rod was abolished in favour of a tripod, which serves to support quite a new form of sighting rod (or, when the position of the sun demands it, a reflector which is ingeniously adapted to serve also as a sighting vane). This second tripod is placed about 3 feet from the signalling mirror tripod; being made to interlock, both can be carried when packed as easily as one. But the instruments now issued to regiments in India are provided with a supporting arm which dispenses altogether with the second tripod. This arm, about 16 inches long, is clamped to the base of the instrument and serves to support the sighting rod, or when occasion requires it, the reflector. The points for and against a supporting arm may be summed up as follows:—

It dispenses with one tripod, consequently is more handy, saves a little in weight, and practically wherever a man can get a footing, the single tripod instrument can be set up. On the other hand it is alleged that a high wind driving against a mirror placed at the extremity of a

projecting arm occasions a vibration that affects the steadiness of signals, it makes the instrument top-heavy, a short arm necessitates placing the mirror at a less favourable angle for catching the sun, and thus causes loss of reflecting surface, while a long one increases the vibration, and, what is of more importance, adds largely to the size, weight, and cumbrousness of the box in which it is carried. The time required to set up and re-pack would probably be a little less with the supporting arm.

Horizontal Motion Screw.

For a long time the horizontal motion screw of the instruments manufactured in India was fixed to the signaller's right. This was well enough for a left-handed man, for he could regulate the flash with his right hand by turning the screw as the sun apparently worked round, while he signalled with his left. But as left-handed men are the exception, the position of the screw was condemned, and in the more recent issues, just before the Afghan campaign commenced, the screw was on the left hand side, thus suiting all right-handed signallers. In Mance's 3-inch heliograph (and I understand in all his instruments), the revolving plate and horizontal motion screw are so constructed that the screw can be placed right or left, which is of course a great advantage. This is effected by fixing the screw to the metal piece which fits on the tripod, and not to the base of the mirror. In the Roorkee patterns, the screw turns itself as well as the mirror round the tripod.

Mirrors.

Various methods have, from time to time, been adopted in India of securing the mirrors to their frames. When breakages occurred, it was remarked that those which were fastened with screws connecting the rim and frame, generally cracked from screw to screw, showing probably that the glass was pinched at those points. Some heliographs received from the Roorkee Canal Foundry had the mirrors secured without screws, a tight-fitting rim over the mirror seemed to keep it firmly fixed in the frame. Mr. Mance puts the mirror in at the back, padding it with a few slices of cork and then screwing on the thin backing of metal which rests on a flange in the rim and does not touch the glass. With this arrangement breakages are said to be extremely rare.

While on the subject of mirrors it may be useful to remember that glass can be cut under water with a pair of scissors. Spare mirrors were ordered to be sent to Kuram, but no mention was made in the indent that they were required for heliographs with screws fastening the mirrors between frames and rims. The mirrors arrived and the edges had to be cut to allow the screws to pass through, this was done by holding the glass under water and cutting it with a pair of scissors.

Telescopes and Stands.

A really good telescope and strong serviceable stand ought to be

issued to regiments for the signallers, who should be practised in their use and taught to read signals at long distances. As a rule, men strain their sight by trying to read with the naked eye instead of using a telescope, and a man is constantly seen delaying over his message by calling for more " light," when with the aid of a telescope he could read straight through without an interruption.

With the Kuram Force, the telescopes and stands were of all sorts and sizes, some large and cumbersome, others small and fragile; with regard to the telescope stands there were none that answered the requirements of supporting the telescope firmly in position and with the means of speedy adjustment in any direction. As a rule the men had to improvise rests, or place the telescope on rocks. It is very important that a signaller should be able to settle down comfortably at a telescope steadily fixed, when reading messages.

Sighting Vane.

The sighting vane proved the weakest part of the heliograph during recent trials on field service. The cross edges constantly became disconnected from the circular rim. The chains to which the silver discs were attached broke, and the discs were lost. It was difficult also to adjust the discs when the men's hands were cold. The sighting rod with the instrument supplied by Mr. Mance was far preferable, no part of it can be lost. The alignment is rapidly altered, for, being jointed, the vane can be raised or lowered or moved to the right or left, without shifting the tripod. The aluminium disc is permanently fastened to a strong steel shaft, and is of sufficient length to enable the signaller to see the shadow spot when the key is not depressed, *i.e.*, the rise and fall of the shadow spot can be plainly seen while signalling.

Fastening of the Signalling Key to Frame of Mirror.

The signalling key in the Roorkee pattern is attached by a piece of metal and small screws to the frame of the mirror; these are quite unequal to the strain, and soon work loose. It should be screwed to the circumference of the frame where there is more metal to receive the screws.

Boxes.

All reports agree that the heliograph boxes are not sufficiently strong, and the cleats inside for securing the instrument, supporting arm, and sighting vane, sometimes broke or dropped out, but these and all other defects of the kind will no doubt be attended to in future.

Mance's cases are constructed to serve as a stand for the instrument, should the situation render it more expedient than the erection of the tripods.

Spare Component Parts.

The Officer in charge of any signalling operations in the field should have a case fitted with spare mirrors, screws, springs, &c., and a few simple tools. Sometimes, for the want of such appliances, an instru-

ment had to be sent to Roorkee for repair, at a time when it could probably ill be spared.

Coloured Spectacles.

A few coloured spectacles should be provided, for the constant strain of reading signals when there is a glare or high wind is very trying. But signallers are not sufficiently careful of their eyes, and especially when using a telescope, they generally press the eyelid and eye-ball of the closed eye with their fingers when looking through a telescope, instead of simply screening it with the hand hollowed in such a way that no portion of the eye experiences any pressure. They ought to practise reading right and left eyes alternately, so that the strain may not always be on one.

Message Books.

The new form of message book, with a division ruled for each letter, was universally condemned and the old pattern procured when possible; the signallers found great difficulty on a cold morning in keeping the letters within their limits and the messages were always more difficult to read than if they had been taken down in the ordinary manner.

The CHAIRMAN: There is an instrument on the table which, I think, has not been explained; perhaps Major Wynne can give us some account of it?

Major WYNNE: I understand this looking-glass was used for flashing signals between Etchowe and the lower Tugela, and presume the flash was directed by means of two sighting points which I explained in my lecture are necessary when an impromptu heliograph of the kind is worked. The signalling was then probably carried on by obscuring and exposing the flash with the board which served as a shutter.

Major MACGREGOR: I should like to ask Major Wynne if he can recommend any really good portable instrument—something sufficiently small and portable for an Officer to carry.

Major WYNNE: Yes; I have here a 3-inch Mance heliograph very suitable for any individual to carry—mounted or dismounted. It is efficient to upwards of 30 miles, is very light and fits into a leather case with straps to buckle to the D's of a saddle, or it can be slung over the shoulder occupying no more space than a pair of small binoculars. The mechanism is the same as that of the 5½-inch instrument exhibited and explained this evening, except that the smaller one has a supporting arm instead of a second tripod.

The CHAIRMAN: I believe that it is not very steady with the supporting arm?

Major WYNNE: That is one of the objections urged against it, that a reflector at the end of an arm in a high wind is liable to quiver.

Major MCGREGOR: As I was at Etchowe I may be permitted to confirm what the lecturer has said, that an instrument may be used as small as a shaving-glass. We did send messages through, from Etchowe to Ginghilovo, with a sixpenny shaving-glass, and two rough sticks to take the alignment. I simply held the glass in my hand, and shut off the sun with the skirt of my coat.

Major A. C. HAMILTON, R.E.: I may perhaps be permitted to say a few words on the subject of signalling by heliographs, as I was placed in the position of Director of Military Telegraphs and Signalling during the Zulu Campaign. We employed the heliograph to a very great extent, having at times 15 or 16 different signalling stations. The greatest distance between the stations was 35 miles, the general distance being from 20 to 25 miles and sometimes less. At the commencement of the movement of the second division, General Newdegate's division under Lord Chelmsford, there were only 3 pairs of heliographs available for that

column, a pair of large 10-inch Mance, a pair of 6-inch, and a pair of 3-inch ones. The 3-inch ones had been given to some cavalry signallers of the 17th Lancers who had learned the use of them in India, when in the 16th Lancers, from which regiment they were volunteers, and they were most useful throughout the whole of the operations. They took the most advanced positions and carried their 3-inch heliographs on their saddles. I may mention that those 3-inch instruments were rather imperfectly constructed, and the heavy wear and tear of four or five months completely wore them out, so that the threads came off all the screws, the tripods became broken, and we had great difficulty in working them. Shortly afterwards Sir George Colley brought from India some of the Roorkee pattern. I am sorry that Major Wynne was not able to show us some of these. I consider that they were far superior to the Mance heliographs. They only required one tripod, and the sighting rod was supported on an arm. We never found that the length of the arm to support the sighting rod or reflector caused any inconvenience or any unsteadiness. The only objection I had to it was that it had to be kept loose, while you were adjusting the sighting rod or the reflector, and then the mere tightening up of the clamp, owing to some imperfection in the manufacture, raised or lowered the end of the sighting rod, so that after you had adjusted it, you found, on tightening it up, that the instrument was out of adjustment on the distant object. What I should recommend to be added to the Roorkee pattern, which is otherwise an extremely useful instrument, is that both the sighting rod and the reflector should have slow-motion screws attached to them, (which would add but little to the weight), so that you could either adjust the sighting rod or the inclination of the reflecting mirror by means of a screw. The 10-inch heliographs which we received were altogether too large for use on service. I think they would be extremely valuable in a fortress where it might be necessary to signal to very great distances, 40, 50, or 60 miles, to a neighbouring fortress if such a one were visible; but the 10-inch instrument is extremely clumsy to move about, and it required a pack-saddle and horse or mule to carry a pair of such instruments—the two weighing about 120 lbs.

Mr. GOODE: I should like to ask Major HAMILTON a question. He has spoken as if the Roorkee instrument and the Mance were two distinct things; would he kindly explain in what respects they differ?

Major HAMILTON: The Mance instruments which we had were the 6-inch instruments similar to those now in the room, and some 10-inch instruments with heavier tripods. In each case two tripods were used. The Roorkee pattern that I spoke of is of a different pattern, having only one tripod with an arm. The whole machinery was very much lighter. I never weighed one against the other but the Roorkee pattern was of lighter construction; it was very handy, and on the whole I think worked better than the other. The springs were more satisfactory in their working.

Mr. GOODE: I asked in what respect they differed in principle or in construction.

Major HAMILTON: The general principle of the two was the same.[1] In the Mance heliograph there were two tripods, one for the sighting rod, and the other for the heliograph, while the Roorkee pattern had but one tripod, and the sighting rod was at the end of an arm.

Colonel GODWIN-AUSTEN: Major Wynne has mentioned that the first occasion on which the heliograph was used on service was in the Jowaki Expedition. The first experiment made with the heliostat on service was in the Dafla Expedition in Assam under Brigadier-General Stafford by Captain Begbie, who was sent up to join it from Madras, with two or three native signallers.

The force started from Narainpur in the plain and at first marched through 25 miles of country covered with dense forests, very flat and level, where signalling could not be carried on; but when the force entered the hills and got on the first crest, 5,000 feet high, many of the hill peaks were then cleared for the survey operations, and Captain Begbie was enabled to commence signalling. After we had

[1] In order to avoid misapprehension it should be stated that the Roorkee instrument is a modified form of the Mance heliograph.—ED.

passed the first range of hills and entered the Dikrang Valley signalling was carried on to the extreme point that was reached, viz., the last village that was occupied by the force. The extreme direct distance to which the signals were carried from Narainpur to the first signal station on the Tauir range was 20 miles, and from that to the extreme point, Nanang's village, was 10 miles more, which saved the great distance of 8 marches by which the force penetrated into the hills. In the trigonometrical survey of India the heliostat, or heliotrope as it is called, has been used for many years. It was first introduced into the service by Sir George Everest, Surveyor-General of India,[1] in order to supersede the luminous signals formerly carried on at night. I have frequently used it at distances of 60 miles when carrying on triangulation[2] in certain parts of India.

I may add that a system of signalling by flashes was in use by which the natives employed could be ordered from one hill to another or to cease their work.

Major WYNNE: I knew that the heliotrope had been employed for many years and I have stated so in my lecture, but I was not aware that any heliographic signalling had been carried out during the Dafla Expedition.

The CHAIRMAN: Perhaps Major McGregor would give a little further explanation as to the manner in which the mirror was used at Etchowe.

Major MACGREGOR: At each end of a long straight tube found on the ground, a small piece of paper was fixed. The tube was then aligned on the distant flash. Next, the mirror was set up so that both pieces of paper were lit up by the sun's reflection, and by this means we knew that the flash was visible from the distant station. The sun was simply shut off by means of a board, of course it was the rudest possible kind of arrangement. The real difficulty was that the sun was at our back. The glass had to be sometimes almost horizontal, but it was so large that the mirror had not to be moved except perhaps every four or five minutes; that, however, occasioned a great deal of delay. The sun, being at our back, was in the worst possible position; we tried every sort of means of communicating by balloons, rockets, a very large screen almost as large as the map on the wall, flags, and bonfires at night, and they all failed. But this system at last succeeded; it was exactly this day last year that we first succeeded.

Lieutenant-Colonel W. L. YONGE, Royal Artillery: We have had a very interesting account of the success attending the use of the heliograph when the sun is shining, as it does for six days out of the seven in India; but in this country we have very little sun, and, as the lecturer has stated, the signalling would probably be confined to flags on sunless days—almost every day in the year. Major Wynne states that when there is an interval of 4 or 5 miles between the stations a flag of the required size is so heavy that it becomes almost impossible to work it for any length of time "as it entails much physical labour, and is tediously "slow," are we then to understand that where there is no sun and where the distance is anything like 5 or 6 miles, all army signalling is to cease? I am opposed to the Morse system except where the heliostat or the heliograph must of necessity be used, viz., for extreme ranges. There is so much trouble in learning the dot and dash system, and as a fact so few men do learn it thoroughly, that it is not available when it is wanted for every-day use. Major Wynne does not seem to have been much assisted by the "*signallers*" sent to him. They had had no special training

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[1] About 1833.

[2] This last statement connected with triangulation is somewhat misleading; I have never actually observed angles to a heliotrope with a theodolite beyond 36 miles, but I have seen flashes from one in the Naga Hills at the greater distance mentioned above. There is in clear weather and with a large mirror, as Major Wynne, I think, mentioned, practically no limit, if the points be visible with the aid of a telescope. It is quite as important to state that during the very thickest haze in the spring in the Garo Hills I once observed angles at 13 miles when the peak on which the distant station was situated was quite invisible to the naked eye, but the heliotrope showed in the field of the telescope like a tiny star. In such a state of the atmosphere a telescope on a stand would be necessary, and the true bearing and elevation of the station known.

with the heliograph and they were of no use to him until he had taught them himself. I think that flags are not to be depended upon for accuracy at moderate ranges, and that some system much simpler than "the dot and dash system with "flags" should be tried. I refer to my own clock-vane system, of which I spoke here about a year ago; I do not now intend to enlarge upon its advantages, but I should like to know what substitute is proposed when the flags cease working at distances of about 5 or 6 miles, and when there is no telegraphic communication between detached brigades or outlying camps.[1]

Major Wynne: I hope it has not been inferred from any of my remarks regarding signallers that I wish to disparage those who worked with me. There were certainly a few who though qualified with the apparatus used at home were uninstructed in the heliograph, but they soon acquired the requisite knowledge, and I merely mentioned this to show the importance of training *all* army signallers in the use of the instrument. The signallers with the Kuram Column worked well and cheerfully, any success attending the operations whilst I was in charge, I owe to them. With regard to a substitute for flags and heliographs for distances exceeding what can be accomplished by the former and on days when sun-flashing is impossible, I know of none and am not acquainted with Colonel Yonge's clock-vane system; still I believe that with the rapid strides in artificial light a flash sufficiently strong to be discerned for considerable ranges might be reflected from the heliograph on dull sunless days, seen at very long distances, and to a certain extent would take the place of the sun.

Major Hamilton: During the autumn manœuvres of 1872 the lamp was used a great deal, and the first intelligence of the advance of the northern force on the Wiley was communicated in the middle of the night of the 4th of September, through one of the intermediate stations, in the midst of a thunder-storm. I merely mention the fact to show that the lamp was of some use on that occasion.

Major Le Mesurier, R.E., Inspector of Army Signalling: I did not intend to say anything with regard to the heliograph to-night, because all my knowledge of it extends only to theory. In this country we have but little opportunity of using the heliograph, and I have had no practice in signalling out of the country. It is said that lookers on see most of the game; I have been a looker on for some time, and am by profession a looker into the matter, but unfortunately I have seen nothing of the real game; I wish that I had had the same opportunities as Major Wynne has enjoyed. A question has been raised with regard to flags, and the general impression seems to be that they are altogether too heavy for use; there has been, however, a small flag introduced lately, by which we can send messages without any effort in this country at the minimum rate that Major Wynne has referred to in the case of the heliograph, namely, ten words a minute, and with one hand alone messages can be sent at eight or nine words a minute with as little labour.[2] In a warm climate I can understand the importance of diminishing to the utmost the exertion required from signalmen. With regard to what Major Wynne has said on signalling in general, my experience, extending over some years in the matter of instruction, bears him out entirely. With reference to the efficiency of the men and the necessity of training them carefully, he has used almost the same words that will appear in the next edition of the Manual now under revision.

Captain A. Abercrombie Jopp, late R.E. (Director General of Stores for India): I should like to ask one question with regard to the mechanical arrangement of the instrument with which Major Wynne has worked. We have heard to-night some comparisons between two existing patterns. Now in certain inquiries which it has been my duty to make with regard to sending out heliographs to India, some doubts have arisen whether, after such an instrument as we have had described has been in use for some time, the distinction between the dot and dash is not apt to be rendered a little difficult; the dash is to be three times the length of the dot, and the dot ought to be as short as possible; but it is evident

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[1] See Journal of the Royal United Service Institution, vol. xxiii, page 658.

[2] This flag gives the advantage to signalling over mounted orderlies at any distance beyond a flat mile gallop, even for a single message.

that if anything occurs to lengthen the dot, the dash ought also to be prolonged, in order that the proportion of three to one may be maintained. It has been suggested that in the instrument which we have seen, the little rod between the key and the mirror is apt in hot or wet weather to be slack or to bend, and thus to prevent a clear definition between the dot and the dash; and the whole message is consequently delayed. I should like to ask what has been Major Wynne's experience on this point. There is no patent in a mirror nor in the sun; what we want is to get the means of communication, by the agency of the mirror and the sun, in a sufficiently practical form for working clearly and rapidly in the field.

Major WYNNE: Of course if an instrument is not in perfect gear it will not work truly. For some years past improvements have gradually been made in the construction of heliographs, and I consider those here to-night (two Mance's 5½″ and one 3″) certainly as good, if not better than any I have seen.

In my "notes on the construction" which I have thought of too technical a nature to read this evening, all the weak points according to my idea have been explained, the chief of which is the connection of signalling key to mirrors, the screws soon work loose and the "dot" and "dash" become difficult to read, the flash sometimes passing over the line of sight and at others failing to reach it; this defect has been remedied in the instruments now before you, for you will observe the signalling key is attached to the thick rim and not to the thin back of the mirror frame, which is the case in the Roorkee pattern. The position and weakness of the horizontal-motion screws, I have also alluded to as imperfections which do not appear in the Mance patterns.

Of course if any part of the instrument is out of gear, the signalling is inaccurate. Then there was another great defect—this spring was never strong enough, and after a short time you could not keep the instrument inclined so as to suit the flash exactly to the apparent motion of the sun.

The CHAIRMAN: I will now ask you to give your thanks to Major Wynne for the very interesting paper he has read to us on the heliograph. I think we owe a great deal to that instrument, not only on account of its use, but because it has raised the importance of army signalling very considerably. So long as the art of signalling merely consisted in the transmission of messages by means of a flag, it was very doubtful whether it was really worth while to keep it up or not. The distances were so short over which you could signal, that (as Major Wynne has very justly observed) a message sent on horseback would go as fast as, if not faster than, a flag signal. But it must be remembered that although flag signalling may not be of great use in itself, as we have other means of transmitting messages by lamps and by the heliograph, &c., it is still a useful mode of training signallers, because the same system is used throughout—the Morse alphabet—whether you learn it by a flag or by a flash, or by any other means, it is the same alphabet. Another point that has come out in the paper and the discussion is the great advantage of the heliograph in an enemy's country where there is plenty of sun, as in India, for while a telegraph wire may be damaged and cut, the rays of the sun cannot be intercepted. The last part of the discussion has had reference merely to the mechanism of the instrument; of course there may be many improvements as we go on working with the heliograph before we get a perfect instrument, but after all the system is the same; it is merely flashing the sun's rays by means of a piece of looking-glass—a very old story; but the instrument may be, and no doubt will be, perfected in time. We have now to look to night signalling, and I think the great question we have to solve is how to get at the best means of transmitting messages by night, and what sort of lamp or light is best to be used. There I think the ingenious men amongst us may exert themselves with advantage.

Friday, March 19, 1880.

Admiral Sir FREDERICK W. E. NICOLSON, Bart., C.B., Vice-President, in the Chair.

ON THE PRESERVATION OF BOILERS.

By Rear-Admiral C. Murray Aynsley, C.B.

The subject of the paper that I have the honour to read to-day is of so much importance not only to those afloat but also to the thousands on shore who use steam power, that I much wish some one better versed in the art of clearly laying facts and opinions before an audience (a power that I on this my first appearance cannot expect to possess) was in my place now.

The information I intend to lay before you was chiefly acquired while serving on the late Admiralty Boiler Committee, which was directed, as pointed out in their Lordships' letter of the 5th June, 1874, to visit the dockyards and principal seaports to, as far as possible, take evidence of witnesses conversant with the subject, examine into the construction and mode of working boilers both in the Royal Navy and in the mercantile marine, take into consideration the properties and qualities of materials used in their construction, and consider fully in what way surface condensation has affected their durability, and what measures are to be taken in the future for their preservation.

To carry out these comprehensive instructions it was necessary to visit not only the Royal Dockyards, but also the great seaports and manufacturing towns of the country where, although through the courtesy and goodwill of the gentlemen we met every information in their power was freely afforded us, we found that nothing definite was known on the subject, and that to render our report of any value we required, for foundation, a comprehensive and extended series of experiments, to be carried out on a small scale at first, but eventually having the results verified by the working of new and other boilers both on board sea-going vessels and on land.

Although in the course of the afternoon I have to allude to other types of boilers, I shall assume that for marine purposes the circular tubular boiler carrying a pressure of from 50 to 200 lbs., and working surface condensation engines, is the type of the future.

As our inquiry proceeded, we saw that great differences of opinion were held by engineers not only regarding the cause of decay, but also as to the effect of surface condensation, the predominant idea being that though it had in some cases caused more rapid decay than jet condensation, yet that with proper care, surface condensation ought not to be more injurious to boilers than the old system.

When, however, we required information as to why decay occurred, then there were still more numerous and conflicting opinions as to the causes that produced it, and consequently as to any appropriate measures which should be adopted for its prevention.

The causes to which corrosion was attributed were as follows :—

1. Water too pure from constant condensation.
2. Fatty acids from oil used for internal lubrication, &c.
3. Quality of the iron used.
4. Particles of copper carried in by feed.
5. Galvanic action between boiler and condenser.
6. The use of copper feed-pipes.
7. Bad management of boilers.
8. Copper in solution.
9. Use of copper internal pipes.
10. Chemical action.
11. Mechanical action.
12. Softening effect of distilled water upon iron.
13. Absence of air in water repeatedly condensed.
14. Too much blowing.
15. Decomposition of water, &c., &c.

With such differences of opinion there were, as would be expected, equal differences as to the method of working, and in particular as to the time water should be retained in the boilers.

The extreme difference is shown by two of the cases brought to our notice; in one the boiler was filled at Hamburgh with the river water, and went to Callao without increasing the density beyond $\frac{1}{32}$. On the return voyage the boiler was filled with sea-water at Callao, and on arrival at Hamburgh the density was scarcely $\frac{2}{32}$. The total time under steam on the two runs being 109 days, no change of water taking place at sea. In the other case, besides filling the boilers no less than five times in 38 days, the quantity of water blown out was as much as 84″ per diem, the density being from 16° to a maximum of 19°.

We found fresh water frequently used for filling boilers when starting on a voyage. Sometimes the boiler was refilled at short intervals, all the water being changed; in other cases more or less of the water was blown out during short stays in harbour, no change taking place at sea; again, the boiler being filled in harbour, the waste was made up at sea either with fresh water carried in tanks, or in the double bottom, or from the sea.

Mineral oils were commonly used for internal lubrication in preference to those of animal or vegetable origin.

I will now, in order that you may be better able to appreciate the conditions of working which either insure reasonable durability or contribute to the decay and corrosion which it is so necessary to avoid, place before you a few illustrations taken from the many cases which came under our notice, selecting for this purpose those simple ones which, when compared, will best exhibit the chief causes of general decay.

Amongst the exceptional types of boilers one on the tubulous

system was examined by order, with a view to making a special report. It consisted of a series of tubes, the heat being applied outside, was always worked with fresh water, the waste, which was very small, being made up with distilled fresh water; certain of these tubes being selected by us were taken out and cut up for examination; when the connection was cut, although the boiler had not had steam up for some time, the air was heard rushing in, showing that when not in use a vacuum was maintained in them, and on being cut open, a burr, as perfect as when the tube was fitted twelve years before, was found where one of the smaller tubes was screwed into the larger one. This boiler was worked at a very high pressure, and its good condition is, I believe, attributable to the non-admission of air in this system of working.

Some Lancashire boilers at Oldham may also be instanced as examples of great durability; we saw one that had been just opened to have the usual thorough overhaul at the end of five years. On these occasions the front plate is taken off, and the whole of the interior taken out. The iron tubes were as perfect as when they left the makers, and after they had been cleaned in a lathe would be returned into store for re-issue. We saw some that were being placed in the boiler, many of them re-issues with the bloom on as perfect as if new; and judging from what we saw, as also from what we were told, there was no reason why some of those taken out might not have been ten years at work. The water used in these boilers passes through a feed-heater, and is much contaminated by sewage; it requires to be filtered from the amount of solid matter in it, so much so that a few years ago the smell was so offensive that clean water was substituted, but as in a short time it was found that the boilers were suffering from corrosion the use of the dirty water was re-introduced. At these works a tea made from a substance from Finland was used as a boiler fluid, but I believe that the feed-heating, combined with the use of water having therein a large amount of organic matter, was the cause of the good result.

Another case of good condition, resulting partly from the presence of sewage and organic matter in the water, was found in the boilers of boats in the port of Bristol; all showed well, and there was very little corrosion for the time that they had been at work. In several of these boats the condensers were fitted outside under the run, and in this plan there was so little air to deal with, that no air-pumps were required.

In another line of steam ships occupied in a coasting trade and making short voyages, it was usual to keep the boilers full for six weeks, and to avoid blowing off during that time, when in harbour closing all valves, &c., and keeping a vacuum; this method of working resulted in a very good condition of the boilers at the time of our inspection.

The cases of rapid decay which were brought to our notice were, as may be imagined (excluding those in the Royal Navy), of less frequent occurrence than those of a contrary character. But amongst those that came before us, I will mention that when surface condensation was

first re-introduced into marine engines one large steam ship company had some engines fitted so that the air-pumps also did the duty of feed-pumps. The boilers were filled with fresh water, and any waste was made up with distilled sea-water from a boiler set apart for that purpose. These boilers went with great rapidity; in one case being seriously pitted after from ten to eleven days' steaming; in other cases, after steaming from 8,000 to 10,000 miles, the boilers were in such a bad condition that the system of working was changed, feed-pumps being added at the same time, by which means the rapid decay was stopped, and the boilers were given an extra life. The benefit derived was attributed to the change of system, but it is more than probable that the addition of feed-pumps, and thereby avoiding the introduction of so much air, contributed in a much greater degree to this improvement.

We had it also in evidence that the most rapid corrosion known to a gentleman of special knowledge on the subject was not in boilers used for steam, but for boiling water for washing clothes, &c., these going much more rapidly than in those fed with the same water, and used as boilers for engine purposes.

A very instructive illustration of the corrosion to which iron is liable when the action is reduced to its simplest form, was afforded in the condition of some of the steam pipes forming part of the system used for heating the Houses of Parliament. The water from which steam is raised comes from the deep well in Trafalgar Square, and while the boilers themselves are practically free from corrosion, some of the wrought-iron pipes which convey the steam many hundred feet away suffer from oxidation, in some cases to such an extent as to cause perforation of the tube. So that the only conditions which are available for explaining the corrosion in this case are steam (partly condensed, of course) and air.

In some cases the water supplied to boilers is for economical purposes passed through feed-heaters, and we always found that the corrosive action was expended upon these feed-heaters, thereby relieving the boilers of the corrosion which they would otherwise have suffered. When feed-heaters were first introduced they were made of wrought iron, but in consequence of their rapid decay it was found advisable to substitute those made of cast iron, as being less vulnerable to corrosive action.

Experimental confirmation of some of the different conditions involved in cases of durability or decay were obtained by experiments conducted at the ordinary temperature and pressure; they were on a very small scale, but will be sufficient for the present purpose. Strips of polished boiler plate from Yorkshire iron being immersed in sea water or distilled water with or without access of air :—

Bottle No. 1 contained distilled water, the upper end of the strip being just covered by the water, the mouth of the bottle was incompletely closed by a cork.

Bottle No. 2 contained distilled water, which was boiled in the bottle to expel air, a similar strip to that in No. 1 was then intro-

duced, and the water again boiled under the air-pump at a lower temperature to ensure the complete expulsion of air, some mineral oil was then poured in, and the bottle well corked and waxed over.

Bottle No. 3 contained sea-water and a strip of iron, the other conditions being exactly similar to No. 1.

Bottle No. 4 contained sea-water, and was otherwise arranged exactly as No. 2.

These bottles, with some others which I shall presently describe, remained in the Committee Room at the Admiralty for twelve months.

Oxidation commenced immediately in Bottles 1 and 3, the water becoming turbid from the presence of oxide of iron (rust), which formed continuously until it had collected at the bottom and sides of the bottle in considerable quantity. At the end of the period, the strips were withdrawn, cleaned, and weighed; they had lost respectively in grains per square foot per ten days:—

No. 1, distilled water	8·27
No. 3, sea-water	5·76

The strips in Bottles 2 and 4, with the exception of a slight tarnish, remained as they were put in; there was no oxidation, the water being quite clear.

Now you will be in a position to understand why it is so desirable to protect boilers not only when under steam, but also when out of use, from access of air; and by comparing the known conditions under which oxidation took place, or was prevented altogether in the bottles, with the conditions in the working of boilers, examples of which I have instanced, you will readily see why there should be decay in some cases and durability in others.

We found that in some ships the remedy adopted was the substitution of iron for all the copper pipes connected with the boilers, and in one case iron was used even for the steam pipe. In another case, air was pumped into the boilers, and this remedy has been gravely recommended by officials, although not carried out by the principals.

Washing the interior of the boilers with cement was a practice of some firms, and with very satisfactory results. It was, I know, tried some years ago in the Navy, but not approved of, probably because it was laid on too thick, and the use of freshly-burned cement not insisted upon. In one firm the superintending engineer was in the habit of having a quantity of mineral oil introduced the last thing before closing.

A curious remedy for corrosion in land boilers common in Lancashire consisted in putting a dead pig into a boiler that showed signs of pitting, and the engineers in some few steamers used to go on shore with a sack, in which any unfortunate cats, &c., were collected for a similar purpose. A story is related that an engineer of a ship in China told the ship boatmen to bring off some dogs or cats for the boilers, but the man answered him that they were worth too much money, though if a dead Chinee would do he would find plenty. The origin of this custom is not known, but the introduction of organic matter is

doubtless beneficial when used for the purpose of preventing corrosion by the oxygen contained in air brought into boilers with the feed. Among the remedies for corrosion in boilers I might mention some which in many cases are applied with useful effect, such as an alkaline solution of organic matter, which acts (especially under pressure) in a similar manner to that last alluded to in the Lancashire remedy for pitting.

A common remedy for supposed acidity of the water in boilers, or in order to neutralize the effect of fatty acids, is found in the use of soda, usually in the state of carbonate. In some of the boiler compositions or fluids, usually of a proprietary nature, alkali and organic matter are found mixed together.

Among the remedies for corrosion the use of zinc was strongly advocated by some marine engineers, while others did not attribute any real advantage to it, in some cases even discontinuing its use. The contradictory opinions as to its value were plainly due to want of knowledge of the principles involved when the electro-chemical relations of two metals immersed in sea-water had to be considered, and in the few cases where a decided advantage could be traced to the zinc there can be no doubt that metallic continuity, which is absolutely essential to success, had been accidentally effected.

The common method of using the zinc was to suspend it by means of a hook from one of the stays, sometimes under water, sometimes in the steam space, but in a Liverpool line of steamers, in consequence of the slabs of zinc coming down before the zinc was consumed, clip hooks were adcpted; on arrival in port after each run, the boilers and stays were carefully cleaned, and the wasted zinc plates replaced; now to clean the boilers thoroughly the zinc had to be removed, consequently not only was any replaced zinc put into the boilers at the last moment before closing, but many of the good slabs taken down for convenience while the boiler was being cleaned were replaced when the new was put in. By this arrangement a large proportion of the zinc would be, unintentionally it may be, in metallic connection with the boiler surfaces, and in this company all the engineers declared that zinc was of great value in preventing the corrosion of their boilers.

I have now to consider the means which have been adopted for preventing corrosion in empty boilers.

This condition has in former years been one of the chief causes of decay to the boilers of ships in the Royal Navy, because iron rusts or oxidizes most rapidly when exposed in a moist state to free access of air. Until within a comparatively recent date, the treatment of an empty boiler consisted in drying it by means of bogie fires, and if a condition of absolute dryness could have been effected during the whole time in which the boiler was open, the decay would doubtless have been diminished, but considering the nature of the surfaces, and the shape of the boilers so treated, there must have been an amount of decay which is avoided by the present methods of treating boilers out of use. The precautions against decay now adopted are—

1st. What may be called the dry method consists in drying the boiler

in the old way; then pans filled with well burned lime are placed in several parts of the interior, and lastly, before closing up, a quantity of ignited charcoal or coal is introduced, in order to withdraw as much of the oxygen as possible from the air shut up in the boiler; to ensure the success of this method the sea cocks must be perfectly tight.

2nd. By the wet method of preservation, the boilers are filled quite full with water up to the safety valves, the water being rendered alkaline by the addition of either lime or soda.

3rd. The oil process used in the case of the gunboats hauled up on the slip at Haslar: oil being run into the boiler until full, and then pressure applied and kept on for a day, is so distributed over the whole of the interior, that when run off, a film is left, which dries and protects the interior surfaces from decay; here, however, the boilers are new.

In the mercantile marine, where boilers are seldom out of use except for short intervals, chiefly during repairs, the precautions I have mentioned are unnecessary, and in this comparative freedom from exposure lies their immunity from the decay which we have been considering.

As a precaution against the accidental admission of air to the interior of boilers out of use, it is advisable to render the water alkaline either by the addition of lime or soda—and for the purpose of illustrating these conditions, strips of iron corresponding in every particular with those previously mentioned, were immersed in bottles containing—

1. Lime-water, solution of caustic lime in distilled water.
2. Sea-water, rendered alkaline by a limited quantity of carbonate of soda.
3. Sea-water with an excess of carbonate of soda.

In these cases corrosion was entirely prevented so long as the alkaline condition was maintained, and at the end of twelve months the strips were quite bright, as when introduced.

Another series, in which there was free admission of air to sea-water of different densities, showed the following losses:—

In sea-water of $\frac{10}{32}$ densities, loss ..	2·81 grains	per square foot in ten days.
" $\frac{6}{32}$ " ..	3·13 "	
" $\frac{3}{32}$ " ..	6·52 "	
" $\frac{1}{32}$ " ..	6·79 "	
Fresh water from main	8·33 "	
Distilled	6·17 "	
Distilled from sea-water	6·38 "	

Those figures which represent the loss in sea-water of different densities are interesting in so far that sea-water of high density appears to possess less power of absorbing and transferring air to iron than the water containing an ordinary amount of salt.

I shall in this place only notice seven of our experiments at Devonport. Three of these consisted in working or treating boilers as we had previously proposed, viz.:—

1. To wash the interior of boilers with a coating of Portland cement.

2. To cover the interior surfaces of a boiler with mineral oil.

3. To retain the same water in a boiler for as lengthened a period as possible, so long as the density did not rise beyond $\frac{6}{32}$.

4. To ascertain the protective value of different qualities of zinc.

5. To determine whether zinc lost any portion of its efficiency through the loss of connection by riveting the plates together.

6. To compare the action of the water in jet and surface condensers upon iron.

7. To illustrate the corrosive action of feed-water, and the diminished action of the same water after it had passed through the heater upon the boiler.

1. A. The interior surfaces of a land boiler were thoroughly cleaned and washed with fresh Portland cement; this boiler was inspected from time to time; the adhesion continued always perfect and gave full protection to the surfaces, no spots of oxide being visible; and however much the cement might appear to be worn off, a scratch with a knife always showed that some of the cement remained.

B. One of the old rectangular boilers in the tug "Perseverance" (surface condenser) was, after some months' wear, cleaned as far as the nature of the boilers would admit, and washed with cement; the adhesion was very good, and, although no zinc was used, there was but little sign of decay at the end of two years.

C. Several boilers in course of construction were also treated in the same manner. First, before the heating parts were put in and again afterwards—the boilers were kept open for some months in the boiler shed before the mountings were attached. There was no sign of rusting, and the cement, if rubbed with the hand, was quite dry and dusty.

2. The interior of the other boiler of "Perseverance" was painted with mineral oil. It stood the work perfectly, and, after six months' steaming, the surfaces were quite oily. A similar experiment in the "Assistance" troopship failed, but the difference of pressure and consequent temperature (the "Perseverance" carrying only 30 lbs., while the "Assistance" carried 50 lbs.) will fully account for this.

3. The "Perseverance" retained the same water in her boilers for over six months, but in consequence of a freshet in the harbour at the time she ran them up, more solid matter was introduced than usual, and, as the quantity was gradually increased, it became necessary to empty the boilers, not because the density was too high, but on account of the priming caused by the solid matter. At the commencement of this experiment the density of the water in the boiler was 9°, and at the end of six months it had only risen to 24°, or about $\frac{2\frac{1}{2}}{32}$. I wish to draw special attention to this experiment, even in its limited form, because it disposes of a notion which till within a recent period was extremely prevalent, viz., that it was necessary for the welfare of a boiler to constantly change some of the water; the reasons which were assigned for this practice being various, though

mostly illogical. In the days of jet condensers, the rapid increase of density was a reason sufficiently obvious; but when surface condensers were introduced the density no longer increased with the same rapidity, and yet the practice continued, though with tight condenser tubes the water returned to the boiler from the hot well should contain scarcely any solid matter.

Possibly the old custom and the general idea that it was necessary to blow off at $2\frac{1}{2}$ densities, together with the direction on many salinometers to do so at that density, may have caused a continuance of the practice, but a little consideration will show that it is a positive disadvantage; for example:—

1st. Hot water is blown out and cold water substituted; this means a loss of fuel.

2nd. Water is blown out which has parted with some of its sulphate of lime, and water is substituted which contains its normal quantity, thereby constantly adding to the amount of scale upon the heating surfaces; this also means a greater expenditure of fuel, and an unnecessary opening up of the boiler in order to scale it.

3rd. Water is blown out which, by boiling, has been freed from air, and water is substituted containing its usual quantity of dissolved air which contributes to the decay of the boiler.

Had it not been for the accumulation of mud in the boiler of the "Perseverance" the same water might have been retained for a much longer period, or until the density had risen to double what it was when the accidental necessity occurred for emptying.

I have specially dwelt upon this point because, even at the present day, there are marine engineers who tenaciously adhere to the traditions of the past, and who consequently incur all the evils which are inseparable from an unscientific method of working.

At the same dockyard the "Trusty" tug, with jet condensers, only required to change the water six times in over five months.

A tubular marine boiler working a land engine in the dockyard retained the same water for six months, and was in an excellent condition when opened, and at the end of eighteen months' work file marks were still visible.

4. The zinc slabs in a boiler of the "Trusty" were of three qualities, viz., zinc "bottoms," ordinary commercial zinc, and a third of extra good quality; the results being that the plates lost in grains per square foot per ten days—

With best zinc	2·02
,, commercial	15·14
,, bottoms	18·08

5. Slabs of zinc were bolted on to a bright surface of two iron bars, each being in two parts; in one case bolted together through drilled holes with turned bolts; in the other riveted in the ordinary manner. The losses per square foot in ten days were as follows:—

Bolted	33·15
Riveted	36·16

6. Here by some error the piece intended to have been in condenser

of "Trusty" was placed in the passage to the hot well. The losses were per square foot in ten days—

Condenser of "Perseverance"	133·67
Hot well of "Trusty"	802·07

7. Plates were placed in four positions, two in buckets plunged in the feed heater, one being filled with water from the main, another with water from the condenser, a third in feed heater fed with overflow from the two buckets, and a fourth in the boiler. The losses were per square foot in ten days—

The plate in bucket filled from the	main, lost......	25·16	grains.
" "	condenser	38·37	"
" "	feed heater	40·52	"
" "	boiler	1·90	"

but the second and third of these plates were, after a considerable time had elapsed, found to have been protected with oil showing no corrosion; if this be taken into account, the loss will be—

From main............	25·16
" condenser........	79·87
In feed heater..........	84·37
" boiler..........	1·90

Two series of pieces cut from the same plates of iron and steel showed the following average loss during ten days:—

In "Perseverance" boiler,	steel,	22·63
" "	iron,	17·92
In feed heater,	steel,	78·62
"	iron,	71·43

The former being salt and the latter fresh water.

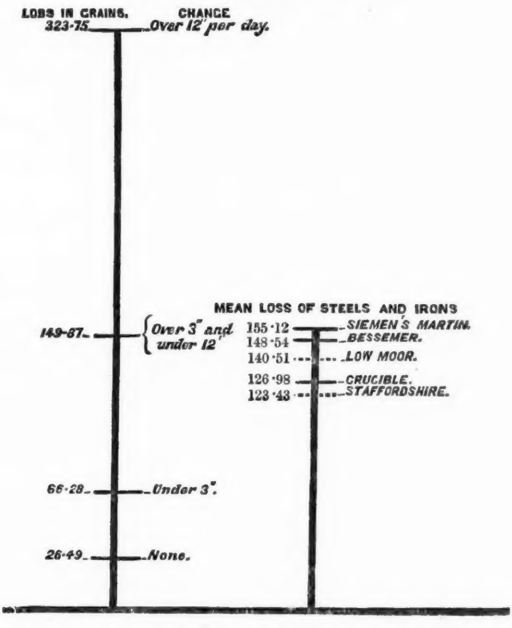
I now proceed to describe a more extended series of experiments called in our Report the Ocean Plate Experiments, and which unfortunately at the time of the dissolution of the Committee in March, 1878, were not in a sufficiently advanced state for us to do more than allude to them. The object of this series of experiments was to determine what method of practical working at sea caused the least decay, and at the same time to ascertain whether, as in the Sheerness experiments, there was a difference in the amount of corrosion suffered by different varieties of "steel" as compared with iron when subjected to the same conditions.

A number of sets of plates, including in each set three of steel and two of iron, were arranged in the same order, and in such a manner as not to interfere with each other. The plates had bright but not polished surfaces, and were all of the same dimensions, viz.:—4 inches square and $\frac{3}{8}$th in thickness. An insulated set of these plates was suspended in such a manner as to be uninfluenced by any condition except that of the water, in one of the boilers of men-of-war on the Mediterranean, West Indian, Pacific, Australian, China, Brazil, Cape, and East Indian Stations, troop ships on home and foreign service,

tugs in the home ports, and merchant vessels belonging to no less than forty-five of the principal steam ship companies trading to every part of the globe. A blank form was supplied with each set of plates, in order that the chief engineers might fill in all the particulars with respect to the conditions of working and other circumstances during the continuance of the experiment.

We anticipated that in the collective results to be obtained from so many sources, we should be in the possession of facts which would either modify or corroborate the experience which we had already acquired; and although I am sorry that I have only been able to avail myself of forty-two sets in the preparation of this paper, it very fortunately happens that amongst them there is nearly an equal number which represent the principal methods of working.

OCEAN PLATE EXPERIMENTS.



The loss is given in grains per square foot for each ten days plates were in boiler.

In some few cases, however, certain sets are not available for all purposes—thus, should a boiler worked on the principle of no blowing or change of water prime badly (as in the case of the "Perseverance" before mentioned), it cannot be compared with others as to change

of water, but it is still trustworthy as to the comparative corrosion of steel and iron, and also for mean corrosion.

I will first draw your attention to those results which illustrate the effects of change of water, and for this purpose I shall divide them into four groups:—

1st. Those that do not change any water at sea.

2nd. Those that change 3″ and under every twenty-four hours.

3rd. Those that change between 3″ and 12″ every twenty-four hours.

4th. Those that change over 12″ every twenty-four hours.

It would have been instructive to subdivide these into boilers filling with sea-water and fresh water; boilers making up waste with sea-water or with fresh water carried in tanks, &c.; also to distinguish between them according to the intervals of changing all or nearly all the water, but the number of results at my disposal will not permit of this.

In the 1st group of 10 sets, the mean loss was 26·49 grains per sq. ft. in ten days.

In the 2nd group of 9 sets, the mean loss was 66·28 grains per sq. ft. in ten days.

In the 3rd group of 7 sets, the mean loss was 149·87 grains per sq. ft. in ten days.

In the 4th group of 6 sets, the mean loss was 323·75 grains per sq. ft. in ten days.

And among boilers in the first group, the plates in those which are emptied at the shortest intervals suffer most.

Now if we read these figures simply in connection with one condition of working, viz., change of waters, you will see how they confirm what I said just now with regard to its disadvantage in connection with the case of the "Perseverance," and that of boilers generally.

In what follows I have not divided the sets of plates into groups, but (except for some special purpose of illustration) include all. The effect of different lubricants in connection with corrosion is when mineral oil is compared with vegetable oil; the losses are—

Mineral	134·81
Vegetable	134·87

but though by this it would appear that the influence of lubricants has been much over-estimated, it is hardly a just view, as all the fourth group use mineral oils; excluding these, the numbers are—

Mineral oils	74·70
Vegetable oils	134·87

thus showing a considerable advantage in the use of mineral oils; but it must be stated that as only four used vegetable oils, the number is too small to give trustworthy data.

We next come to the comparative merits of steel and iron so far as corrosion is concerned, and with the following results (see diagram):—

Mean loss of crucible	....	126·98	Steel.
„	Bessemer	148·54	
„	Siemens-Martin.	155·12	
„	Staffordshire ...	123·43	Iron.
„	Lowmoor	140·51	

Group 1st, mean loss of steel ..	28·04	of iron	26·04
„ 2nd „ „ ..	60·05	„	60·22
„ 3rd „ „ ..	149·49	„	146·34
„ 4th „ „ ..	328·46	„	314·10
Mean with surface condensers..	115·67	„	109·44
Mean with jet condensers	179·42	„	119·38

A further illustration of the effect of change of water may be given in the following results, which were obtained in connection with the first table, by comparing the use of fresh or land water with sea-water:—

Group 1st	F. 28·37	S. 20·51
„ 2nd	„ 48·77	„ 101·70
„ 3rd	„ 73·28	„ 166·38

This shows that while the boiler is what I consider properly worked, *i.e.*, no change taking place, the advantage is in favour of the sea-water, but when the water is changed, the fresh water has the advantage. It must, however, be borne in mind that no zinc was in connection with the plates.

The advantage in using fresh water in sea-going ships will be found in the fact that by filling the boilers with it when opportunity offers at starting on a voyage, the necessity for change on account of increased density is very much diminished, if not altogether avoided.

Two sets of these plates were tested in a steamer that filled the boiler at short intervals with sea or river water, according to the port she was in, but never changed any at sea. One of these sets was suspended in the only feed heater attached to marine engines we were then aware of, the other in the boiler fed with water that had passed through the heater. The respective losses were in grains per square foot per ten days—

In boiler	16·53
„ feed water	93·23

that in a steamer belonging to the same company, running between the same ports, and worked in a similar way, being 37·44.

Considering the title of my paper, viz., "The Preservation of "Boilers," I might have introduced some of the minor causes which are supposed to contribute to decay, such as the fatty acids resulting from the use of lubricants having an animal or vegetable origin; the accidental damages caused by other metals, such as copper, brass, or lead;[1] the oxidation produced by allowing water to lie at the bottom of open boilers; mechanical and solvent action resulting in the detachment of scale or in preventing its deposit, such as the local action of the feed,

[1] One large company has copper tube plates, and with no injury to the boilers.

and so on. Some of these causes which have been assigned for corrosion by marine engineers may contribute in a small degree to the decay of boilers, but many have nothing to do with it, and yet decay is attributed to them, instead of the real cause.

It must be remembered that a boiler is a closed vessel, to which you can admit, or from which you can exclude, what you please, with little exception, and also that what may be detrimental to an unprotected plate of iron in the open sea may be absent or comparatively harmless to the same plate when it forms part of a boiler, because the conditions as to the power to corrode and of the surface to be corroded may be totally different in the two cases.

I would not for a moment discourage all advisable precautions with regard to the mechanical safety of steam boilers, nor attempt to undervalue the inspection which doubtless has often saved many valuable lives; but the constant opening up, more especially of marine boilers, appears on reflection to be unnecessary. If it be urged that opening up is unavoidable for the purpose of scaling, then it may be answered that the accumulation of scale is preventible by a system of working which keeps it out, and it must be possible, by means of mechanical appliances, to exclude most of the dirt which gains access to a greater or less extent. So far as the scale deposited from clean sea-water is concerned, there can be no hesitation in admitting that a limited amount is an advantage, not only because when well deposited it protects the boiler surfaces, but because it offers a better and rougher surface for ebullition than a smooth boiler plate. It is the practice in some ships to carry a supply of fresh water on board to make up waste. This, however, would be, for many reasons, impracticable in a man-of-war, and I will here relate, for the information of shore engineers, what happened to me while in command of Her Majesty's ship "Monarch."

We were off the south coast of Ireland, with ample coal to go anywhere, but as the ship had to try rate of sailing with other ships, I deemed it advisable to run up two of the compartments in the double bottom, next to where the coal had been chiefly taken from. That same day we had to try rate of sailing, and though we had not more than 180 tons of water in the two compartments, which we thought were completely full, the bracket framing kept the water from close filling them, and the ship was like a log, some ships which ought to have been nowhere, beating us. We went the next day into Queenstown, and I succeeded in filling the bottom, adding about 12 tons in all; we went to sea again, and easily beat the other ships, the feeling of the ship as she went through the water being quite different from what she was on the former occasion.

Under steam this evil is less felt, but men-of-war ought to be always in a state to do their best.

I will now briefly recapitulate the treatment which should be observed for boilers during construction, and the system of working which would appear best calculated to give them durability when in use for raising steam.

1. During construction the surfaces should be protected by a wash

of freshly burned Portland cement, three coats being given and repeated if necessary.

2. Zinc should be distributed in such a manner that all the surfaces below the water may be equally protected, great care being taken as to metallic continuity.

3. After the proper amount of scale has been obtained upon the surfaces in the presence of zinc, there should be no blowing off, and that if practicable the waste should be made up by distilled sea-water.

4. There should be a true auxiliary boiler, not only to distil for drinking, cooking, and bathing purposes, but also that by means of a steam pipe to the condenser, it should at a low pressure make up the waste in the main boilers.

5. That the boilers should always be kept full, and steam be got up to expel the air on first filling; if likely to be soon wanted, they should then be closed with the water at the working level under a vacuum, but if not shortly required, they should be kept quite full.

6. That boilers once filled should never be opened, or air permitted to gain access, except for repair, until it is necessary to replace the zinc, the necessary time being determined by experiments, and that with a view of opening boilers as seldom as possible, whenever any zinc is changed, the whole of the zinc should be replaced.

7. That should from any cause the density rise, no change of water be made until it rises to 50°, or even 60°.

The necessary additional fittings to boilers would be a pipe from the lower part of the safety valve to condenser, so as to avoid the waste of steam, and a provision for free egress of air provided for, between the feed pump and the boiler.

I have purposely condensed my paper into the smallest possible limits, in order that during the time at our disposal there may be an opportunity for those gentlemen who are conversant with this interesting subject to supplement my remarks by their own experience, which it is to be hoped has materially increased since the late Boiler Committee first commenced their labours, and attempted to reduce the evil complained of by pointing out the general principles upon which boilers should be worked.

Commander CURTIS: I have a very few remarks to make upon the paper to which we have listened. The whole question of the preservation of boilers appears to be a matter of air. The more anything is exposed to the air, the more it is oxidized of course. Admiral Aynsley referred to animal matter being put into the boilers. The only way in which I can account for the boilers being preserved in a better manner is that the oxygen has a greater affinity to the animal matter than it has to the iron. The same is also the case with respect to zinc. I presume that zinc has a greater affinity to oxygen than iron, or galvanic action when copper condensers are used. Then also with respect to cement, I think possibly in cement there may be a weak point, inasmuch as if the cement gets a blow it will show a weak point (it does not contract and expand with the iron), and any oxygen that there may be in the water will affect that part. Soldiers beeswax their rifles and keep them very clean and free from oxidation, and possibly the beeswax might be found a very good remedy by beeswaxing the interior of the boiler. Linseed oil is also used to polish guns, and it appears a very good remedy for keeping away the air (suggesting

immersing the plates when hot in oil).[1] I think the Admiral said the iron was preserved better in salt water than in fresh.

Admiral AYNSLEY: The salter the water the better the iron was preserved.

Commander CURTIS: There are more animalculæ in salt water, and air has an affinity with the animalculæ rather than to the iron. The great point is the affinity of the air for animal matter and animalculæ rather than to the metals. Moreover, when fresh water is used, it is taken from running water and shallower water, consequently there will be more air, and in consequence more oxygen, the base of acids.

Captain LONG, R.N.: I am not sufficiently acquainted with this subject to make remarks of any great value, but I cannot help rising to express on behalf of absent Officers our gratitude to Admiral Aynsley. This is a subject which I am aware is contained in two enormous Blue Books, which are no doubt very dry reading, and therefore it is the more valuable to have this information placed before us in a concise and intelligible form. With regard to one boiler which the Admiral has spoken about, and which I conclude is the Perkins boiler, I should like to ask whether he knows any reason other than the difficulty of utilizing the high pressure steam generated in such a boiler, which would prevent its introduction into Her Majesty's Navy.

Mr. ROUGHTON: I should like to ask whether Admiral Aynsley includes the preservation of boilers from the risk of exploding. Whenever a boiler explodes, there is this palpable peculiarity, that the iron plates of which it is composed are lacerated by a force which can be calculated. The strength of iron is pretty well known: you can calculate the internal steam pressure which tears the plates asunder, and this is seldom less than 400 lbs. to the square inch. There is, therefore, evidently a very wide margin between the pressure at which boilers are ordinarily worked and that pressure which is sufficient to cause an explosion. I therefore propose a very simple expedient for rendering all boilers perfectly safe from explosion, and that is, by affixing to the boiler a little cylinder made of zinc or other material with a calculated strength of 10 or 20 lbs. greater than the working pressure of the boiler, and yet some hundreds of pounds less than the force which would cause an explosion. This principle I think is very simple. The strength of a boiler is ordinarily ten times the working pressure. I would venture to suggest that this principle may also be applied to guns. Guns we all know do sometimes burst with terrible effect; every gun is necessarily made much stronger than is sufficient to resist the ordinary working pressure, or, as you would say, the normal pressure of the gunpowder. The strength of a gun is not less than three or four times that required to sustain the pressure of the powder, and therefore a little ingenuity would be able to apply the same principle to guns, and that I imagine, when guns are made of such enormous size, is rather a valuable hint.

Mr. JAMES WRIGHT, Engineer-in-Chief, Admiralty: I should like to say a few words, as I have been connected in a small degree with the investigations carried out by Admiral Aynsley's Committee, and also with some additional investigations afterwards. I have not one word to say against anything Admiral Aynsley has advanced, but on the contrary, I should like to add my testimony in the strongest manner to the correctness and truth of everything he has brought forward. When the Committee took up the investigation of the subject of boiler corrosion, it was completely involved in obscurity. Anyone who reads through the evidence of the witnesses before that Committee, would be surprised to see the great variety of opinion that prevailed on the subject. Opinions of that kind are so imbedded in people that it takes a long time, a long inquiry, and a long series of experiments to sufficiently convince them of the erroneousness of their notions. However, thanks to the patient and long inquiry which has been made, the subject is now rendered perfectly simple and perfectly clear, as all of us who have listened to Admiral Aynsley's paper are quite satisfied. It is not necessary that I should refer to any matters of

[1] There is another "factor" or element in the destruction of boilers, friction, by the convection of the water in boiling. We all know running water will wear away rocks, and vessels' copper is worn thinner at the waterline and bows than elsewhere. Heat is energy and motion of particles or friction.

detail, as he has so completely described the prominent features of the inquiry. I would only mention that as soon as the subject was really in a fair way of being cleared up, we took steps to get instructions prepared and issued for the guidance of engineer Officers in the Navy in accordance with the proved conditions, and I think I may say the instructions already are having good effect, especially in the boilers of troop ships, tugs, and other vessels that were put under altered conditions of working or experimental treatment. I am extremely glad that Admiral Aynsley has brought this subject before this Institution, for it will be a means I have no doubt very soon of making the whole subject more familiar to the executive Officers of the Navy, and give them a greater interest in it. I have sometimes heard naval engineer Officers complain that they do not get that support from the executive Officers in the care and management of their boilers that they should reasonably expect. I do not put much stress on such a statement as that, because possibly it is put forward as an excuse in cases where boilers have failed too soon, but at all events the boiler in the present state of things is a necessity, as much so as any other part of the ship, and although I dare say executive Officers consider it a nuisance, still it is a nuisance that must be endured, and I have no doubt with the assistance of Admiral Aynsley's paper, executive Officers will take a greater interest in the state of their boilers than perhaps some of them have been in the habit of doing. I desire further to say how much everybody who has taken any interest in the subject should be indebted to Admiral Aynsley for the great amount of labour and trouble he has taken, and for the very clear and admirable manner in which he has laid these facts before you. It appears to me that this invention of Mr. Roughton's is simply another form of safety valve to prevent explosion. When that safety valve bursts the boiler will be disabled.

Mr. Roughton: It may be fixed on any convenient position. It might be put on the manhole door, and then when it has given out, you will have been warned that a serious accident has been prevented, and would simply remove it; and the cover, which had previously been placed over it, would be placed on the boiler itself, and you would go on working carefully till you could replace it with another.

Mr. Wright: The point I wanted to put was simply this, that when that safety valve or thin box acts, the boiler is disabled by a hole made in it till you put a new safety valve on. With the ordinary safety valve loaded with a weight or a spring, when it acts, the pressure goes down, the safety valve shuts, and your boiler is as good for its work as ever. All we want for ordinary boilers are safety valves of sufficient size, sufficiently looked after, and kept in order. The proposed safety box would certainly deteriorate in course of time, and some day might burst at the ordinary working pressure and disable the boiler.

Commander Curtis: I would like to say just three words in respect to this safety disc. Some twenty years ago I understood Mr. Roughton that he had submitted this elsewhere, and he was referred to one of his brother Officers, and his brother Officer said, "The fact of the matter is, we would much rather have boilers "that do not burst." Of course that is preferable, but unfortunately they do burst, and not only is it the case that lives are lost, but the boilers become useless. After the accident comes the inquiry to find out the cause. I think it is much better to prevent the cause by applying one of these discs, and then with a simple pair of dividers put across it, you would feel the pulse of the boiler at any moment by the expansion of the disc. We know that safety valves have not always answered, for unfortunately in one of our ships, in the "Thunderer," a new boiler burst and created great devastation. We do not want to find out the cause after the effect has taken place, we want to prevent the effect, and that can be done by this means. Humanity demands that some such application should be applied to boilers, and a cheap method such as this would be a great advantage.

Mr. Roughton: This is not a substitute for a safety valve. Safety valves are constantly in use whenever the steam pressure gets a little above what is ordinarily required, but is intended for an excess of pressure of some 10 or 20 or 30 lbs. more than the boiler was ever intended to have, and the argument is, it would still be some hundreds of pounds less than that which would burst the boiler.

Colonel Clinton: No mention has been made of common grease, which has a wonderful effect; but it is so simple a thing that people do not like the idea of

handling tallow. That is the real reason why it has been neglected. I question, however, whether a dressing of common grease would not be best of all.

Admiral AYNSLEY: In speaking of beeswax and grease, we must remember heat has to be taken into account, and I expect that you would find, however carefully the interior of a boiler had been beeswaxed, the moment you got up steam its benefit would be lost; linseed oil is not suitable for lubrication; but mineral oil has been tried, and at low temperatures it did, as I have mentioned, succeed. In cement, however, which remains on at all temperatures, we have a coating to which the lime scale from water adheres well, and by its preventing the oxygen liberated from the water coming in contact with the iron, renders the use of any other substance for that purpose unnecessary. Regarding animalculæ in sea water, the water that did best was water of 10 density, and as the density was reduced the corrosion increased. To obtain that water of a high density the water was boiled until the greater part was evaporated, so that although the animalculæ would not have passed off, and there would actually have been ten times as much animalculæ in the 10 density as in the 1 density water, the benefit I consider arose from other causes, as we must remember that in distilled water, where there can be no animalculæ, the loss was less than in the fresh water from the main, where in all probability they were present. In answer to Captain Long, this lecture has been entirely with reference to durability. I have elsewhere given my opinion regarding Perkins' boiler, but to-day I only alluded to it as an example of extreme durability, and most certainly that is very great. The question now put to me regards type of boilers to be used, and this opens up so large a subject, that it would take a considerable time to go into, in fact would require the full day for the purpose. In the Perkins boiler it is absolutely necessary to use fresh water, but I believe the absolute exclusion of air is the cause of its great durability. Pressure I do not think has anything more to do with it than that it necessitates such small openings, that they are more easily kept tight and in order, than could be the case in a boiler of similar power and ordinary form.

The CHAIRMAN: I believe the only duty I have to perform is to return our cordial thanks to Admiral Aynsley for a very excellent and practical paper. Captain Long alluded to voluminous and heavy Blue Books, which were very dry to read. I will only remind the gentlemen present that this lecture will go into our small and handy Blue Book, which is sent to our members in all parts of the world, and which I think I may say contains a great deal of valuable information.

ON RIFLE SHOOTING IN HER MAJESTY'S NAVY.

By Lieutenant JOHN FERRIS, R.N.

THE sister service, in which great care and attention are bestowed upon the musketry instruction of the men, contrasts with the Royal Navy in a manner which is anything but favourable to the latter; not but that the seamen from the gunnery ships have, and always do, hold their own against all comers at the Wimbledon meetings, but that as a large body the seamen of Her Majesty's Navy do not come up to that standard of good shooting, which is of such vital importance, and rendered so comparatively easy with modern rifles.

Let us consider the general system of blue-jackets' rifle shooting under the following heads :—

1st. What is the present system?
2nd. How is it carried out?
3rd. How could it be made more efficient?

1st.—*What is the present system?*

On referring to the service field exercise book, we find the musketry course for ships in commission, which prescribes the position and aiming drills, also the number of rounds to be fired at the target, together with theoretical instruction, the whole of which have been carefully revised, and rendered simple.

2ndly.—*How is the present system carried out?*

On the Mediterranean station there is a special Officer at Malta whose duty it is to put the whole of the men on that station through their annual course of musketry, and in proof of how well this acts, it is only necessary to compare the averages, and it will be seen that the Mediterranean far excels any other station in good shooting.

The Royal Naval rifle-range at Malta, on which the whole of the annual musketry course takes place, is in as perfect a state of order as could be arrived at: the men are given entirely over to the charge of the musketry instructor (a Gunnery Lieutenant), and have an undisturbed course of each long day's drill, and this devotion of time to one object has obviously many advantages, and contributes to give the men an interest in themselves.

On other stations it cannot but be admitted that a thorough course of musketry is but seldom carried out, though of course it is supposed to be gone through, as laid down in the Field Exercise Manual. Irregular modes of carrying out the position drills, owing to constant disturbances, indifferent rifle-ranges, and too often a general carelessness as to the training of the seamen, all lead to a falling off in the average, and a general inclination to hurry over the course cannot be productive of good shooting.

3rdly.—How could the present System be made more efficient?

It will be seen by reference to the Manual, that in the annual musketry course for sea-going ships, the seaman does not practise at longer distances than 400 yards. Now it is obvious that in the present day of long-range rifles, and hence loose order of skirmishing, how necessary it is that our seaman, like his brother soldier, should be taught to shoot at much greater distances than the above. The reader must remember that in the present course the men are never (since distance is not over 400 yards) taught to fire with the flaps of their sights raised. It may be contested that there is little utility in firing at long distances, when men are but indifferent shots at short ones; but let the reader remember what lessons in the necessity of steadiness are learnt from firing at long distances, and how easy accuracy at shorter distances seems to come after practice at the longer ones.

More time should be devoted to musketry, and other drills disregarded, in order to bring the bad shots into a higher state of efficiency, as cases are not uncommon of finding young ordinary seamen so afraid of their rifles as to miss the target repeatedly at short distances, from sheer nervousness, which could easily be corrected by a few extra drills and more practice on a rifle range.

Each ship should have targets supplied for use on shore, and no expenditure of the quarterly rifle ammunition should take place except at these targets, and this should be done in a careful way, and not hurried over. A detailed return of the ball-practice of each quarter should be submitted to the authorities. Also at an Admiral's inspection more weight should be attached to the efficiency and precision with which the men can use the weapons supplied to them, and on this occasion the musketry averages should be gone into.

In the annual musketry course the number of rounds fired in skirmishing order should be increased and should be fired at longer distances, and some encouragement should be given to the men to obtain high scores in this particular practice.

Lastly, judging distance should be taught most carefully, which of course would greatly improve the men in the skirmishing firing, and render them much more practical marksmen for the field.

In conclusion, let us look round us at the arms used by other nations, and we shall see how rifles generally have become improved; their sighting, for instance, how distant it is! There is our own rifle to 1,400 yards, the Mauser to 1,750 yards, the Berdan to 1,200 yards, the Gras to 1,960 yards. The new pattern American rifles and others all point towards a general idea, *i.e.*, "to open fire at long ranges with "picked marksmen as soon as possible."

The Royal Navy is so often called upon to fight (and well it does fight) in all parts of the world, that a little more trouble and care as to the eye education, and practical good shooting, of its rising generation, would not be lost to the country, whose right arm lies in its welfare. Machine guns and shrapnel shell on shore, electric firing and torpedoes afloat, may do much, but will not always substitute the steady hand and eye of a well-trained marksman.

Longitudinal Se

FIG. 1.

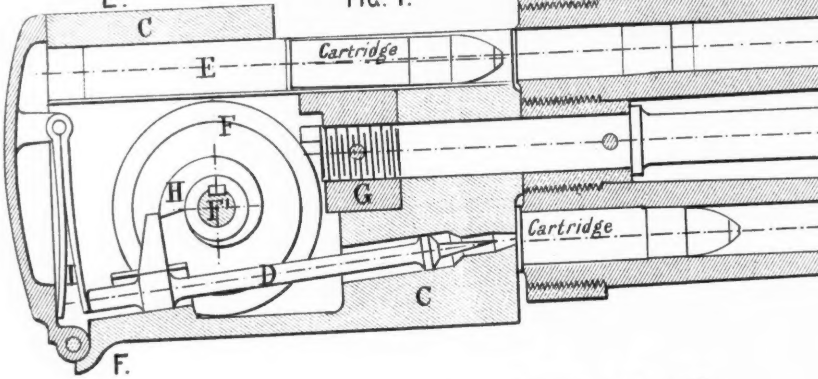


FIG. 2. *Longitudinal Section though* **A.C.**

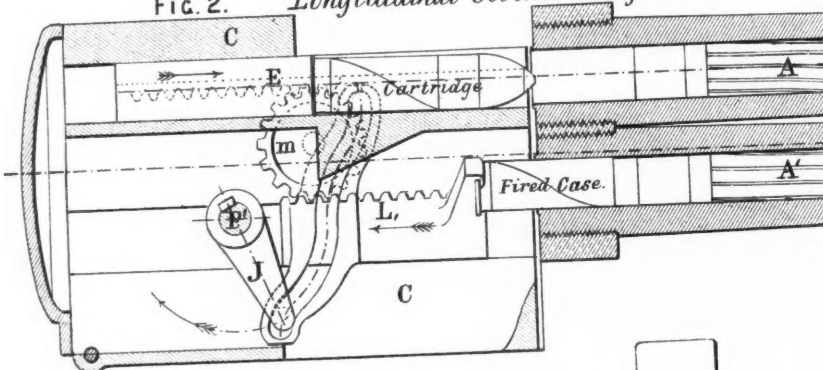
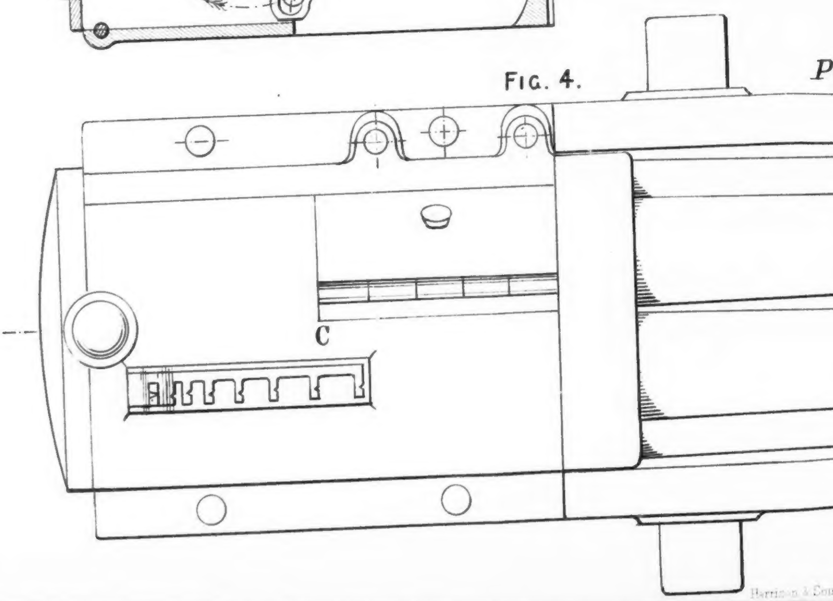


FIG. 4.

Pl



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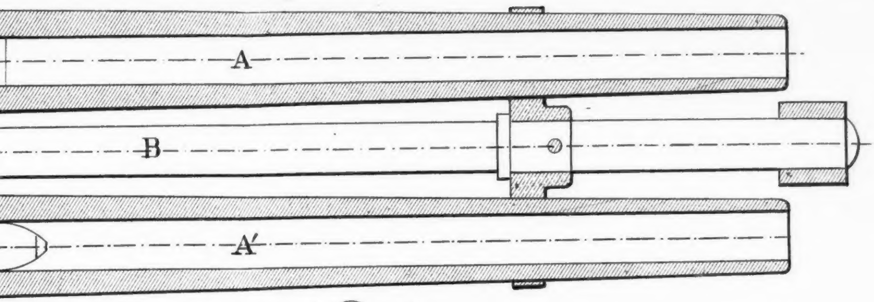
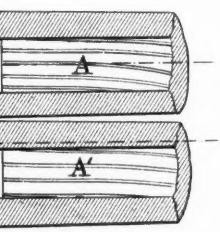
...udinal Section through A.B.

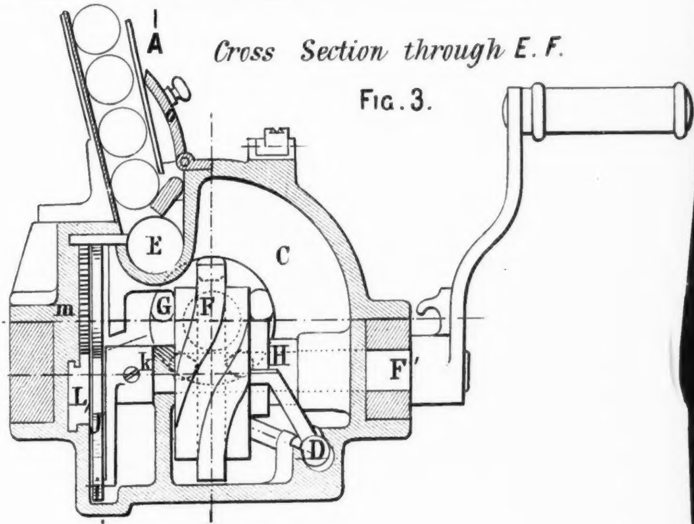


C.

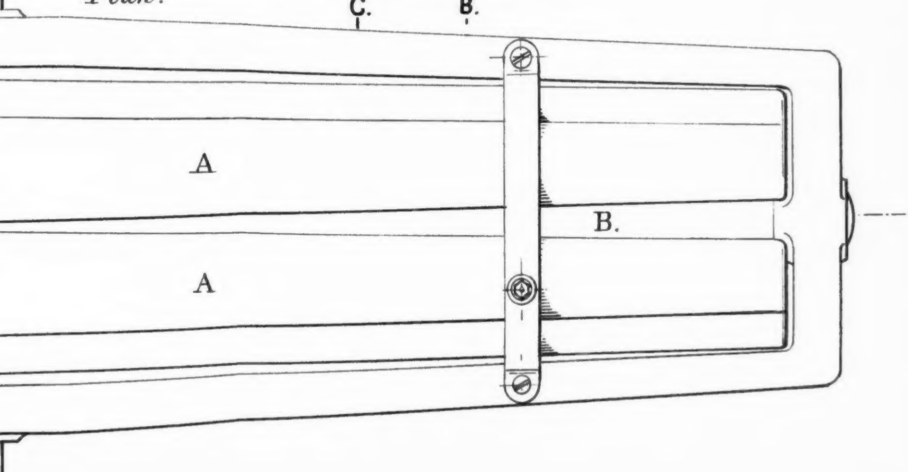


Cross Section through E.F.

FIG. 3.



Plan.



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Monday Evening, March 1, 1880.

REAR-ADMIRAL A. H. HOSKYNS, C.B., in the Chair.

ON HOTCHKISS' REVOLVING GUNS.

By Mr. B. B. HOTCHKISS.

Introduction.—For some years the machine-gun question has become one of great importance to all branches of the Service, for by degrees all countries are introducing one or another system into their armaments. The old argument that men will fire too rapidly and too much at random with rapid-firing guns, and that it would be impossible to supply the amount of ammunition which they consume, is gradually losing force through the better instruction, more thorough discipline, and principally by the improved means at hand for transporting *matériel* and ammunition to the centres of action. Railways have now become as important a factor in warfare as guns, and already several countries have even introduced steam traction-engines into their transport service. We all see how the use of rapid-firing guns and rapid means of transport necessarily go hand in hand, and we shall find a continual augmentation of the rapidity of fire forced upon us for all kinds of arms, from the rifle up to guns of the heaviest calibres.

It was during the late American War that mitrailleuses began to attract so much attention, and after their adoption by France they soon became, we may say, quite the rage everywhere. The practical utility of the *mitrailleuse proper*, that is, the delicate and complicated machine for throwing an enormous quantity of small bullets (or *mitraille*), was much doubted by many military authorities, whilst, on the other hand, others saw therein an arm which would be of considerable value, and which probably would, to a great extent, revolutionize the existing modes of warfare. The Franco-German War of 1870, in which mitrailleuses were used on a large scale, demonstrated, however, pretty clearly the *pros* and *cons* of this kind of weapon as regards service in the field, and in the Army generally; but the practical value afloat is still a good deal a matter of conjecture, although it is generally thought that the true sphere of action of the mitrailleuse is in the Navy.

In regular service, mitrailleuses have usually proved themselves, as we all know, to be of great value in certain exceptional cases; but, on the other hand, their sphere of action is very limited, and it was particularly with the idea of giving a greater scope for the employment of machine-guns, that this revolving cannon was designed,

a gun which should fire explosive shells, and should thus possess to some extent the advantages of artillery fire, besides the rapidity of action and other features of the mitrailleuse. It is to a description of this weapon that this paper is devoted.

Description of Gun.—The Hotchkiss revolving cannon consists of five barrels, mounted parallel to each other, around a common axis, and carried between two gun-metal disks, as in the Gatling gun. This group of barrels, bearing at their front end in a gun-metal frame carrying the trunnions, is rotated in front of a fixed breech-block, which contains the mechanism for loading, firing, and extracting the spent cartridges. There is only one set of mechanism for all the barrels, each barrel being brought successively before the loader, striker, and extractor. The barrels do not rotate continuously as in the Gatling gun, but only make one-fifth a turn at a time, thus bringing, at each movement, the following barrel into the place occupied by the one before it. The continuous turning of the hand-crank imparts this intermittent rotary motion to the barrels, and they are at rest during the period of loading, firing, and extraction. In this manner each turn of the hand-crank loads one barrel, fires another, whilst the spent cartridge is being extracted from the third. This arrangement gives a very simple mechanism, consisting of only few parts, and these can be made large and strong, and, therefore, makes this gun better able to support the rough usage of regular service than other machine-guns which have an independent set of mechanism for each barrel, which, of course, multiplies the number of parts and requires them to be made smaller and lighter.

The mechanism of this gun has the very important advantage of not being in any way subjected to the direct shock of the discharge; this feature is attained by the peculiar manner in which the closing of the breech end of the barrel is effected; this will be easily understood by referring to the longitudinal section of the gun (Fig. 1). A and A′ are two of the barrels; B the central axis; C is the cast-iron breech; D the striker, or firing pin. A cartridge is laid in the receiver above, ready to be pushed into the chamber of barrel A, by the action of the loading-piston E, as soon as the cartridge in the barrel A′ (in the lowest position) is struck by the striker D and discharged. After the barrel A is loaded, it is revolved until it comes in the position of A′, in front of the striker, and the base of the cartridge rests against the solid part of the breech; here the breech is perforated by a hole for the point of the striker to work through. Of course this, like all other machine-guns, uses a complete cartridge holding in each the projectile, the charge and the primer. The gas-tight closure at the breech is effected by the metallic cartridge. It will be at once seen how absolutely secure this arrangement of the gun is, and this is for machine-guns of large calibres a very important feature, for the continuous shock of discharge acting against any kind of lock, or bolt, or other mechanical breech-closing arrangement, is sure, sooner or later, to cause the breakage of some parts of the mechanism. The intermittent rotary motion of the barrels is effected simply by a worm F, of which the

thread is partly straight and partly helical, this worm gears in a pin-wheel G on the rear end of the central shaft B. The worm carries at the same time the cocking-cam H, which retracts the striker and allows it to fly forward at the proper moment by the action of the spring I. This spring is the only one in the gun, all the other operations are done by positive action.

As to the manner in which the loading and extraction of the spent cartridges is performed we must refer to Fig. 2. There is a fixed cog-wheel *m*, mounted on the interior face of the left side of the breech, and two horizontal racks L′ and E′, running in slides. The rack E′, which is attached to the loading-piston E, is placed above; the other, L′, carrying the extractor, under the cog-wheel and parallel to the axis of the barrels, so that in moving one of the racks, the other one is moved by the cog-wheel *m* in the opposite direction. Part of the lower rack forms a curved link, or yoke, in which a small crank, J, works; this crank being fixed on the shaft F′, which carries the worm and is turned by means of the hand-crank operating the whole mechanism. The rotation of this small crank J, of course imparts an alternating and opposite movement to the two racks, so that while the one is going forward, the other moves back, and reciprocally. A spent cartridge case is in this manner extracted, whilst a loaded cartridge is being introduced into the barrel above.

The extractor itself consists of a double hook at the front end of the rack L′. The head of the cartridge rolls into this double hook as the barrels are turned round, and it is so laid hold of, and withdrawn from the chamber as the rack runs backwards; besides this there is an ejector to push the cartridge out of the extractor hooks at the proper time, and it falls out of the gun through an opening in the under part of the breech.

The whole system of the extraction works very positively, and it works equally well at the highest elevation as at the greatest depression, which is 30 degrees. This extreme angle of depression is sometimes required when the gun is used from the tops, or from the bridge of vessels high out of water.

Besides the already described parts of the gun there is an arrangement to regulate the supply of cartridges, called the "feed-gate;" so that only one cartridge can enter the receiver at a time; the rest, which are piled one upon another in the hopper, are cut off, whilst the bottom one is being pushed into the barrel.

Supposing now the crank to be in continual motion:—

Operation of the Mechanism.—A cartridge is placed in the hopper, the feed-gate descends and allows it to enter the receiver in which the loading-piston E moves, this pushes it into the barrel, then the barrels begin to revolve, making at each movement one-fifth turn, and the cartridge is carried on until it arrives at the lowest position and comes before the striker D, which penetrates the solid part of the breech, and which has in the mean time been retracted by the action of the cocking-cam H. As soon as the cartridge has arrived in this position, the barrels cease to turn and the primer of the cartridge is struck and discharged: then the barrels make another fifth turn, and

the spent cartridge-case is carried on until it comes to the extractor L; this in the mean time has arrived up to the barrels, and the cartridge head rolls into it. As soon as the cartridge is laid hold of by the extractor, the barrels again cease to revolve, and during this period the cartridge-case is withdrawn and dropped to the ground. As during every stoppage of the barrels the gun is supplied with a new cartridge, and the firing and extraction is performed during this time, a continuous slow fire is kept up. Each turn of the crank gives one shot, so that when the gun is once laid and fed with sufficient rapidity, about 60 to 80 shots per minute can be fired from it.

Now to recapitulate the manner of operation :—

The supply of cartridges is regulated by the feed-gate, the barrels are loaded by means of the loading-piston E; the intermittent rotating motion is imparted to the group of barrels by the worm F; the cartridges are fired by the striker D, this in turn being operated by the cocking-cam H; and lastly the fired cartridge-cases are withdrawn by means of the extractor L, which is actuated by the small crank J; the movement to the whole mechanism being imparted by turning the hand-crank.

Characteristics of the Hotchkiss Mechanism.—The peculiar and distinct characteristics of the Hotchkiss mechanism are the following :—

1st. Intermittent rotation of the barrels, without rotation of the breech or mechanism.

2nd. The barrels remain stationary at the moment of discharge, the loading and extraction taking place during this stop, thus suppressing the tangential motion with which the projectiles of such guns are animated at the commencement of flight, which have continuous rotating barrels, at the same time suppressing any chance of accident from a "hang-fire" cartridge, as the barrels remain relatively a long time in their firing position.

3rd. The employment of but one loading-piston, one striker with its spring, and one extractor for all the barrels, thus giving great simplicity to the mechanism, and allowing at the same time all parts to be made sufficiently strong and heavy to sustain the rough usage of actual service.

4th. The shock of discharge is received against a massive fixed breech of considerable weight, which distributes it to the whole system; this permits the employment of charges and projectiles only limited by the weight and dimensions thought proper for the gun and carriage, so as to suit the different requirements of the service for which it is to be employed.

5th. The mechanism of the gun is disposed in such manner that no tools are necessary for dismounting or re-assembling the same, and it can be done in a couple of minutes by any ordinary armourer.

The nature of material for the different parts of the gun has been chosen after the result of long experiment. Whitworth's steel is exclusively employed for the barrels. Gun-metal is used for all parts of the mechanism which are subject to sliding motion, so that it is impossible for anything to rust together if neglected and not oiled; then gun-metal is always used for the frame, disks, and some other parts,

and in the naval guns for the pivots, &c., as it has the advantage of not rusting, which is of importance for sea service.

We now come to the ammunition:—

Description of the Ammunition.—Generally with the revolving cannon, a regular cast-iron explosive shell with percussion fuze is used; sometimes in the Navy, where a maximum of punching power is required, hardened pointed steel shot are also used. For flanking the dry ditches of fortifications, and for which a particular pattern of gun has been recently designed, canister shot is used.

The cartridges for all calibres of this gun are made of sheet brass, wrapped, strengthened at the base by two or more reinforcing cups, the whole riveted together, with the head made of sheet iron. In the base there is an ordinary primer in a detachable case, which looks like a little pistol cartridge. These cartridges can be reformed and used about eight times over.

Both the shell and steel shot have for coating, which takes the rifling, a soft brass guiding band of about one calibre in length, and placed symmetrically from the centre of gravity; this guiding band is conical in its front part, corresponding to the cone in the projectile chamber, so that the projectile is exactly centered in the bore as soon as the forward motion commences. You will see from the samples, that before the projectiles have been fired, the guiding band is smooth on its surface, but that after they have passed through the bore, besides the print of the rifling they show a number of grooves which encircle the band; this is caused by the pressure in the chamber moulding the thin soft band into the grooves turned in the cast iron under the band; in this manner there are only the narrow rings which take the rifling, and these are distributed over a large surface of the projectile. This gives an excellent bearing and at the same time but little soft metal is used, and the manufacture is simple and not expensive.

The Different Calibres, their purposes, &c.—Up to the present time, four different calibres of the revolving cannon have been constructed; in their mechanism, number of barrels, and general arrangement they are all alike, they only vary in weight and power, and in the manner in which they are mounted, so as to suit the different requirements of the service for which they are to be employed.

The Light $1\frac{1}{2}$-inch Gun.—The smallest and lightest pattern is the one here exhibited; it has $1\frac{1}{2}$-inch calibre, and weighs 4 cwt. It fires a projectile of 1 lb., and with 2·8 ounces of Curtis and Harvey's No. 6 powder it attains an initial velocity of 1,410 feet, and a maximum range of 4,800 yards. This is the pattern of gun which has been adopted by the Navies of France, Holland, Greece, the United States, Chili, the Argentine Republic, and now recently by Russia and Denmark. It is mostly used for the defence of vessels against torpedo-boat attacks; but of course is well suited for a multitude of other purposes for which light guns are generally used in naval warfare.

The gun as it is here mounted, on a universal pivot, can be laid and

fired by a single man, whilst another supplies it with ammunition. It has been found absolutely necessary, after experiments at sea, that the same man should lay and fire the gun; because the vessel itself is moving, and then the torpedo-boat or other object, which may be advancing very rapidly and continually changing its course and position, would easily avoid the fire of the vessel's guns, unless it were possible to keep them continually sighted on it, and to fire at the actual moment the sight is brought to bear on the boat. All this has been made possible with the revolving cannon. Each turn of the crank corresponds to a shot; the gunner with the shoulder-piece to his shoulder, and with his left hand holding the directing handle under the breech, lays the gun after he has turned the hand-crank so far that it comes just before the firing position, which is indicated by an arrow on the crank; but besides this, the man, by putting out his thumb, can stop the crank without having to look at its position at all; he then lays the gun, and fires it by turning the crank. The motion of turning the crank to fire the gun prepares another round, and he is again ready to relay the gun a second time, and so forth; so you see it is like a little cannon, in which the whole process of sponging, loading, running out, &c., has been entirely done away with; the gun is always ready to fire, no matter with what rapidity the gunner can manage to lay it. At sea, it is generally intended that this gun shall be laid for each round, and the sighting corrected by observing the bursting of the previous shot fired, and not to "blaze "away" ammunition at random, as is usually the case with mitrailleuse guns. The sight which is employed at sea has fixed notches, corresponding to the distances from 200 to 2,000 metres or yards, as the case may be, so that, as the distances change, the gunner may fall from one notch into the other without any loss of time for setting the sight.

For instance, in the case of beating off a torpedo-boat attack, if the boats were discovered sufficiently soon, fire would be opened at about 1,500 to 2,000 yards; then the fire would be slow, as it would take about five seconds before the projectile can strike; as the boat advances at full speed, the fire will be increased in rapidity, so that, should one or the other boat succeed in getting up to within perhaps 500 yards, the rapidity would be 25 to 30 rounds per minute; and at close quarters, when sighting is not necessary each time, 10 rounds (which can always be kept in the gun) can be fired off at the rate of 60 to 80 per minute.

The gunner who charges will commence by putting a few cartridges in the hopper, and he will lay in a fresh one each time a shot is fired, taking care to keep the hopper full as the boat comes nearer, so as to be able, if necessary, to give a salvo of 10 rounds at a critical moment.

Results of Experiments at Sea.—From results of experiments made at sea in different countries, this gun has shown great accuracy of fire. I may cite, for instance, the French experiments at Gâvre, where it gave in the mean 50 per cent. of hits against a buoy of 3 feet diameter, at distances varying from 1,000 yards down to 100.

In Holland, where very complete experiments have been carried out, the gun was placed on board an ironclad under steam, and worked against a target representing a full-sized 75-feet torpedo-boat. This was fired at, broadside on; then through different angles, from 30 to 50 degrees; and, lastly, end on. The lowest percentage of hits was 50, at a distance of about 600 yards. The highest percentage was attained firing in the line of keel, the vessel running $10\frac{1}{2}$ knots, and commencing fire at about 1,000 yards; in this case, 77 per cent. of direct hits were scored.

Last summer, a series of experiments were made in Denmark with both the Hotchkiss and the Nordenfeldt guns, in order to determine which of the two systems should be adopted for the light armament of vessels and boats. The Danish Navy have now, after these tests, decided for the Hotchkiss gun, which gave results as to accuracy, rapidity of fire, perforative power, facility of manipulation, &c., similar to those previously obtained in Holland. At Copenhagen some firing was also done at sea during night-time by aid of the electric light, and it was found that equally good results could be obtained as during the daytime. The explosions of the shells when striking the objects or the surface of the water, gave valuable indications for rectifying the fire, both during night and day.

In Russia, too, very complete comparative experiments have been carried out with the machine-guns of Nordenfeldt, Engström, Baranoffsky, and Hotchkiss: there the trials, besides being made by the regular Artillery Committee, were conducted also independently by different commanders, who had guns placed on board their vessels. It would lead too far to go into the details of these trials here, but the superior results obtained with the revolving cannon have now led to its adoption by the Russian Navy.

Although most Governments who have introduced this gun into their armaments have tested the steel shot as well as shell, all, with the exception of Russia and Chili, have taken shell exclusively, as they have found this more than powerful enough for disabling the existing systems of torpedo-boats; and besides this, it is generally thought that the bursting of the shell inside the boat will cause more damage than a solid shot, which simply may, in most cases, pass in on one side and out through the other, without causing any more damage than making a couple of holes in the boat.

Perforative Power.—As regards the perforative power of this light gun, experiments in different countries have proved that the common shell is capable of completely perforating the steel plating of torpedo-boats of the "Lightning" class up to a range of 2,500 yards, if striking nearly normally, and up to 2,000 yards if they strike within an oblique angle of 30 degrees. The common shell will also perforate $\frac{1}{2}$-inch steel plates up to a range of 500 yards. Within 500 yards range, the shell will also completely perforate the torpedo-boat when she is running end-on towards the gun, and the projectiles striking the boat at an angle of 70 degrees; they will then burst and the fragments will pass through the bulkheads and damage the machinery, &c.

If the shells fall on the deck they will burst after having passed

through, and the fragments will nearly all pass completely through the bottom of the boat, tearing ugly irregular holes in her plates, and putting her in the greatest danger of sinking.

The penetration of these little shells in oak timbers, and the destruction they do, is remarkable; for instance, at 800 yards they will pass through 12 inches of oak, and at point-blank range it takes 22 inches of oak to stop them.

These shells break up into about twenty fragments, of which at least a dozen weigh as much as a musket ball, and these fragments flying about in the inside of a torpedo-boat may be expected to do as much actual as they do moral damage.

The perforative power of the steel shot is of course greater than that of the shell; it is capable of perforating the $\frac{3}{16}$-inch plates of the hull, and afterwards the $\frac{1}{2}$-inch plates of the boiler at about 800 yards range.

Of course, the shells are of the greatest value for sweeping the deck of an enemy's vessel, firing into the ports, for shelling the shore previous to effecting a landing, &c., &c.; in fact, they can be used for anything, whilst the solid shot is better only for certain exceptional purposes.

Light $1\frac{1}{2}$-inch Gun for the Army.—This same pattern of gun, mounted on a carriage, is used for many purposes; then the shoulder-piece is not necessary, and the crank is mounted on the side as in the Gatling gun.

A light steel carriage has been constructed for this gun, with elevating and a lateral training apparatus, and brakes for suppressing the recoil. The carriage weighs 5 cwt., and the gun, with carriage, limber, and all accessories, and 300 rounds of ammunition, weighs altogether 28 cwt. This pattern is particularly adapted for countries where roads are bad and transport is difficult.

Powerful $1\frac{1}{2}$-inch Gun.—The next pattern gun is much more powerful than the one just described. It has also a calibre of $1\frac{1}{2}$ inches, but the projectile and charge are heavier; this gun weighs 9 cwt., its total length is 6 feet 8 inches. The barrels are 34 calibres long. The explosive shell weighs $18\frac{1}{2}$ ounces, and it attains an initial velocity of 1,502 feet, with a charge of 4 ounces of powder. The maximum range is 5,500 yards.

This pattern has been adopted by Brazil and the United States; China and Turkey have also a small number of them. They were used in the United States by General Miles in last year's Indian campaign; the effect of their fire upon the Indians, according to his report, was very demoralizing. Turkey used a few in the Navy during the last war, but no official information about their use could be obtained, although we have heard that a torpedo attack on the "Assar-"i-Tefvik" was successfully repulsed by their aid.

This gun, when mounted on a field carriage, has about the same weight and size as an ordinary field-piece. The total weight of the gun, carriage, and limber, with 300 rounds of ammunition and all accessories, is about 40 cwt.

The bursting of the shell is very regular, the percussion fuzes act well on graze, and there is only a small percentage of failures. Miss-

fires of the cartridge only occur in the proportion of 2 per 1,000; a miss-fire has, however, no other effect than the momentary loss of one shot, because the whole cartridge is extracted in the same manner as a fired case.

In land service the charging is done by means of feed-cases holding 10 cartridges each, as it is not necessary to sight the gun for each round, because there is no recoil and no perceptible change of direction during the fire; so that when the gun is once laid, fire can be kept up as long as desired at the rate of from 60 to 80 shots per minute; this represents about 70 to 90 lbs. of cast iron, and at ranges approaching to those of field artillery. As each shell of the revolving cannon gives in the mean, on bursting, ten fragments of between $1\frac{1}{2}$ and $2\frac{1}{2}$ ounces in weight, besides twelve smaller fragments which are also capable of doing considerable damage to men and horses, this gun is capable of delivering a continuous fire at the rapidity of at least 60 shells per minute, giving 60 dangerous zones of explosion and divided into a hail of about 1,300 fragments of sufficient power to put men, horses, and *matériel, hors de combat.*

If we imagine a battery of these guns during a decisive moment of an engagement, and take the rapidity of fire at only 60 rounds per minute—a figure which can be considerably surpassed—the six guns would discharge about 420 lbs. of iron, consisting of 360 explosive shells and producing about 7,900 dangerous fragments per minute; and this very destructive fire can be brought to bear with great accuracy on objects within the effective range of 3,000 yards, so that it is hardly possible to imagine that anything could exist within the zone of fire of a battery of these guns.

Flanking Gun.—The next variation of the revolving cannon is the one recently adopted by the French War Department for flanking the ditches of fortifications. This gun has a calibre of 1·57 inches; it fires a canister shot containing 24 hardened bullets of $1\frac{1}{4}$ ounces each. By a peculiar arrangement of the rifling of the barrels, of which each one has a different pitch, it is made possible to sweep the whole ditch with a dense and regularly divided storm of bullets, from about 30 feet from the muzzle of the gun down to the end, which may be 300 yards or more. The gun is sighted and fixed once for all in the *caponnière*, so that, in a surprise during day or night it is only necessary to turn the crank, and the gun will discharge 60 to 80 canister shots per minute, consisting of 1,500 to 2,000 balls of sufficient weight to destroy scaling ladders and such like. If necessary, explosive shell can be used with this gun as well as canister shot.

It would lead us too far to give a detailed description of the ballistical features of this gun and how this somewhat curious result is obtained, and the various conditions which had to be fulfilled, to meet the requirements laid down by the engineers of the new French fortifications. The experiments made with the gun in one of the new forts near Paris were conclusive as to its entire fitness for the purpose. On one occasion 300 dummies were put up in the ditch, distributed loosely all over it from one end to the other, and after firing 60 rounds only fourteen of them were untouched by the bullets.

The great advantage of this gun is of course that it is entirely fixed and requires no sighting, and has no lateral motion, so that smoke, darkness, or excitement do not interfere with its work; there is a kind of long inclined trough which carries 40 cartridges, these roll into the gun when the crank is turned, whilst a man continues to feed ammunition into the trough as fast as it is consumed.

1·85-*inch Naval Gun.*—Besides the light $1\frac{1}{2}$-inch gun for naval purposes, we have, at the instance of the French Navy, constructed a much more powerful pattern gun which, too, is particularly designed for service afloat; this gun has a calibre of 1·85 inches, and fires a shell and a hardened-pointed steel shot of 2 lbs. 6 ounces in weight, with an initial velocity of 1,490 feet. The gun weighs 11 cwt., and is manœuvred by the shoulder very much like the small one, but it was found in the first experiments that when the vessel is rolling the gunner could not well work a gun of this weight with the necessary ease and rapidity, so that afterwards an elevating apparatus was added which is worked by the left hand; in this manner the elevation of the gun remains stationary after each round, unless changed by the gunner the pointing in direction is still done by the shoulder-piece as in the light gun.

Besides the addition of the elevating apparatus another improvement has been introduced in the shape of a trigger for discharging the gun, this allows a third man to be employed, who has to furnish the motive power by turning the hand-crank; in this case it is placed on the side as in the "Gatling." The gun is worked in the following way:—One man turns the crank, and makes one turn for each shot; there is a simple arrangement which stops the crank automatically at the proper point, so that no thought or training is required for this work. The captain of the gun points it and fires by pulling the trigger very much as in a small-arm. (Of course there is no recoil.) A third man then feeds it with cartridges. This arrangement at once brought the rapidity of fire and the ease of working about equal to the light $1\frac{1}{2}$-inch gun, and as with this one, the maximum rapidity of fire is now about 60 per minute.

The satisfaction which the system and general arrangement of the light naval gun gave in the French Navy induced them to think of the introduction of this more powerful gun into the service; it should be capable of destroying the superstructure and unarmed parts of ironclads, &c. If we take into consideration the large number of shots which a gun of this class can discharge in a short space of time, it is easy to imagine the damage which can be inflicted on any kind of vessel by its fire. It is intended also to arm some of the large boats with this gun, for it has the advantage of rapidity of fire and great hitting power, which is not much influenced by the movements of the boat; besides this there is no carriage, no recoil, no running out, sponging, &c.

At point-blank range the steel shot passes completely through $1\frac{3}{4}$-inch steel plates, the shell perforates 1-inch steel plates and bursts after having passed through them.

2-*inch Gun.*—The largest revolving cannon made up to the present

time has a calibre of a little over 2 inches; it fires a shell weighing about 4 lbs., with 1,500 feet velocity. This gun works equally well, and with nearly the same ease as the lighter guns; of course the rapidity of fire is somewhat less, as the heavy ammunition cannot be handled and fed into the gun with the same facility as the lighter cartridges.

Particular advantages of the Hotchkiss System.—On examining the systems of machine guns a little closer, it will be seen that a gun firing shell possesses many important advantages over a regular mitrailleuse (that is, one which fires bullets) for the following reasons:

Firstly, from a mechanical point of view:—To get similar effects to those of the mitrailleuse, on for instance, men and horses, for of course the bullets cannot be of much use against *matériel*, by far slower action of the mechanism of a class of gun like the revolving cannon is only required, because each shell on bursting gives a number of fragments, 15 to 20, which are equal to as many bullets. Taking now for instance the pattern of revolving cannon you see here exhibited, the shell weighs just 1 lb., that is about 2 ozs. over the weight allowed by the St. Petersburg Convention for explosive bullets; this gun firing at the average rapidity of 60 rounds per minute would furnish $60 \times 15 = 900$ fragments, about equal to as many bullets from a Gatling, or other mitrailleuse, of the same weight. You see from this that the mechanism of a mitrailleuse has to work about fifteen times as rapidly as that of a machine-gun firing small explosive shells to produce a fire of similar effect, as to number of bullets and weight of metal thrown. Now, a mechanism which only has to work slowly can be made to work more reliably, is much simpler, and is much larger and stronger than one which has to perform all the operations about fifteen times more rapidly. The wear and tear is also reduced, less accuracy and fine fitting, and care by the armourer are required; sand, rust, and dirt do not so easily interfere with the action; shaking about during transport and rough usage generally, does not easily damage it, &c. I could count up a dozen more features which point to the advantages of any machine-gun which works slowly over one of which the mechanism has to work rapidly.

Secondly, from a ballistical point of view:—We have in this system an advantage over mitrailleuses, in the larger calibre: this gives greater density per unit of surface to the projectile, and consequently, with similar initial velocity, greater terminal velocity at fighting ranges, therefore a better trajectory, and dangerous zones of greater extension. In addition to this there are all the advantages of explosive shell fire, which as to moral effect, actual destructive power, and for giving greater facility to rectify the pointing, is of the greatest importance. For repelling torpedo attacks, the large irregular holes which the explosive shell tears in the hull of a torpedo-boat are far more destructive than the small round holes of a bullet, which can generally be stopped with a plug of wood, and which in many cases do not even let water in if the boat is running fast, and the holes are not just in the bow. A coating of india-rubber too has been tried, and found to afford good protection against the holes made by bullets, but it was found that

the explosive shells tore large fragments of it off, and this protection was thus rendered useless against the fire of the revolving cannon.

One advantage, however, exists in the mitrailleuse; viz., the possibility of using ordinary service small-arm ammunition. Of course in many cases this is important; besides this, a mitrailleuse for small-arm ammunition can be made lighter than a revolving cannon, but this feature does not appear to be so essential when we take into consideration how little in any case the gun weighs, in proportion to the weight of ammunition, and the carriages for transporting the same. Then in the case of use on board a vessel, there is the difficulty of handling these large quantities of cartridges on deck under fire, and getting them up into the tops, and handling them there; also the enormous space required for storage, &c.

If the weights of the different machine-guns with the adequate proportions of ammunition, and the means for carrying the same, be compared, it will always be found that the larger calibre guns, firing shell, require less total weight to attain similar effects.

I would cite, in support of this assertion, the comparative experiments carried out by the French Navy at Gâvre, which proved that in firing against six targets at 2,000 yards range, representing a battalion of infantry in columns, divided into pelotons, the number of hits per kilogramme of ammunition expended was as follows:—

For the $1\frac{1}{2}$-inch "Hotchkiss"	2·59
„ 1-inch "Gatling"	1·45
„ 0·65-inch "Gatling"	0·90

Finally to examine the guns from an economical point of view:—roughly speaking, the larger the calibre, the cheaper in proportion is the gun.

In the ammunition, a similar advantage exists for the larger calibre. The mean cost per foot-ton of effective work, the cost per square inch of section of hole made by the projectiles which strike, and the cost per weight of projectiles which hit the mark, will be found infinitely lower for a class of gun like the revolving cannon than for any mitrailleuse.

Lieutenant ARMIT, R.N.: I should like to ask the lecturer a few questions on the subject we have listened to, especially as I was fortunate enough to see the second machine-gun ever invented in actual use in warfare. I am speaking of the Montigny. You will all remember the scare that gun created amongst the German troops prior to the actual hostilities of the Franco-German War; the soldiers thought this gun was going to annihilate them, but when they came into actual action it was found to do very little harm indeed; in fact, except that on one or two occasions it mowed a complete lane through the attacking columns, it did very little. The Germans were on the guns before the guns could do anything. There was no scattering motion; and I have seen men here and there simply riddled with bullets. The Montigny gun, I think, proved its inefficiency during that war. Since then, the first gun invented—the Gatling gun—has been the most generally adopted; and from what we have heard this evening, it seems that the gun before us is really and truly a Gatling gun. I can scarcely see any difference between the Hotchkiss and Gatling gun, and the systems appear to me to be exactly the same. We know the history of new inventions is very curious in many cases. Here we have, so to speak, a Gatling gun with a large bore. It is perfectly competent to the inventor

of the Gatling to give us a weapon of any calibre. In this gun that you have before you there is one defect, I think, you will all detect. Supposing the extractor failed to act, by drawing off the head of the cartridge, there would be no remedy; you would have to cease firing till you had remedied the defect, for that barrel could not be used, and there is no means, so far as I can see, of continuing to fire with the remainder of the barrels. In the experiments I witnessed the other day at Shoeburyness, a Gatling cartridge did jam, and I saw the lock removed in about two seconds and the gun continued with five barrels, just as well as if the other one was in use, with this exception, that one cartridge was continually being thrown out. That, I think, is a fact that should be taken into consideration in discussing the question of these machine guns, because machine-guns, as a rule, will mostly be used, I suppose, at close quarters; and if, just as the enemy is making a rush, your gun becomes disabled, he is on your gun before you can do any damage. In many cases during the French War from the explosion of German shell in the Montigny batteries, I saw the French mitrailleuses temporarily disabled. I examined many shortly after they were captured, and found they were not permanently disabled, but they had been disabled for a sufficiently long period to enable the Germans to be upon them, and the position to be captured. In the case of this Hotchkiss gun, if the extractor simply takes off the head of a cartridge, I do not see what you can do until you have extracted the remainder of the case, and to do that you would have to take out the whole mechanism and use an extractor or other tool which I suppose would be supplied for the purpose. In the Gatling, as I have seen to be the case, the lock would be taken out, and the gun could be fired in about two seconds with the same rapidity as before, the one cartridge being thrown out. Then, again, with regard to the rotary motion in this gun. The axes of the barrels are not parallel; but in the Gatling the axes are all parallel, and the targets I have seen made at Shoeburyness show conclusively that the rotary motion does not affect the accuracy of the fire. It is not the same thing as trundling a mop and whisking off drops of water. The axes of the barrels being parallel, and the bullet having to traverse the length of the barrel, when it does leave the barrel, which is in motion, it retains its direction, and, as the targets I have seen show, makes very good firing indeed, and fires with great efficiency and accuracy. With regard to penetration, I saw, the other day, a report of some trials at Whale Island, and it was said the Nordenfeldt gun penetrated a 1½-inch plate. As the inventor of that gun happens to be behind me, I dare say he will be able to corroborate my statement. The Hotchkiss gun, we are told, only bulged the plate, the shell exploding and doing no further damage. Then, again, you have in this gun a hand scattering motion. I think, in action, an automatic scattering motion, only to be used when required, would certainly be more advantageous than having to depend upon a man accurately working his body to point and scatter; because a man in action is disturbed from various causes, such as shell whizzing over his head and bursting around, bullets, dust, stones, &c., all flying about him, together with comrades falling beside him. All this must, to a certain extent, unnerve a man, and he may not keep his eye exactly on the enemy, he may fire too high or too low. But if you have the automatic scattering motion, you are obliged to fire in a direct line, because iron has no nerves, while a man has. That this gun should be able to inflict damage on any class of vessel will of course depend on the position in which the gun is placed with respect to that vessel. If the gun is in the tops of an enemy's ship it would of course be able to sweep the decks, as we saw done in the "Huascar" the other day; but on board ship you have the rolling of the vessel and several things to take into consideration. There is no doubt, if you can get accurate aim on a port, and can keep up a constant fire on that port, it would to a certain extent impede the fire within the battery; but such a regular fire would, I think, be very uncertain and difficult to obtain. You might, perhaps, send one shot out of 200 or 300 into the port, but I do not think you would be likely to send more. They would strike about and around the port. If it is simply claimed that this gun is firing a heavier shot than other systems, I do not see that can be claimed as any improvement over other systems for this gun, for the simple reason that other systems are just as likely to increase their calibre as the present inventor has been to increase his. He has seen the demand for a heavy calibre of gun caused by the

advent of torpedo-boats, and he has brought out a gun very similar, in my opinion, to the Gatling. In doing so, he has, perhaps, gone ahead of the inventor of the Gatling, but I do not think he has done anything which it is not equally competent for the Gatling to do. The calibre can always be increased in any system so long as weight is no object. You could have a machine-gun of any size of bore ir you had the means of moving it about. In action, safety is of course the great thing in all firearms. If the firearm is not safe to the man handling it, he can have but very little confidence in it, and you do not get the use out of it that you should. This gun, with the exception of jamming, which is possible, appears to be perfectly safe, because the principle, so far as it goes, is exactly similar to the Gatling. The Gatling has two inverted spirals by which the plunger is driven forward, as in this gun; the only difference being that in one part of the spiral Mr. Hotchkiss has a straight line. I do not see what advantage that is, because arresting the barrels in their motion is simply losing time; as long as you have sufficient firing surface to prevent any backward motion from the discharge, I do not think we should arrest the barrels to fire the gun. All you want is to ensure the cartridge not being blown back or any escape of gas igniting any other cartridge. Here you arrest the barrel; whereas, if you were to go on, you would gain time and fire more rounds, and, if your aim is accurate, do more damage. With regard to the stowage of ammunition, I would only remark that I do not think there would be much advantage gained by this system over the small-arm ammunition. On the other hand, when you are at close quarters you would throw more bullets of the small-arm type than of these large shells; you would handle smaller ammunition more readily, and it would be easier to store in the tops of vessels. Small-arm ammunition, on the whole, I think would far more demoralize a crew exposed to its hail than would the few shots you would be able to fire with this gun in the same time.

Lieutenant CAMPBELL, R.N.: Without attempting to take up the time of this meeting in comparing this with other machine-guns, I think that this gun goes very far to gain the good opinion of naval Officers, on the ground of simplicity of arrangement. If inventors would always remember that requirement, I think they would be more successful. The lecturer seemed to confine his gun entirely to repelling attacks by torpedo-boats, but I think it has a much higher business before it. I think in a fleet action in approaching the enemy the power to sweep his decks is a very important one, and these revolving guns have a great work before them in that respect. In taking vessels into action, the Captains and Admirals have to be somewhere on deck, and must keep their heads cool, and manœuvre their ships so as to counteract the manœuvres of their enemies. They have to do this in a very short time, and they have to do it while they are exposed to the fire of these guns. No doubt in future wars these revolving guns will have a very considerable something to say in deciding the issue of an action. I think that this gun seems to meet all the requirements of the Navy, so far as it has been explained by the lecturer this evening.

Captain BROWN, R.N.: Would the lecturer explain by the diagram what would happen if a cartridge became fired prematurely, especially with reference to damaging any portion of the mechanism, and also the action of the explosion upon any other cartridges feeding the gun?

Admiral JASPER SELWYN: I think we ought to discriminate between this gun as brought before us now, after the torpedo-boat attack has been very largely developed, and the gun made before that time and with totally different views. Evidently this gun is very much fitter to be used in defence against the attack of torpedo-boats for many reasons, but at the same time, I should utterly demur to the statement that any shell fragments have an equal range or power to a stream of bullets. There are two distinct things to be kept in mind: the one is that the shell on exploding distributes its fragments around it pretty nearly in a circle, governed to a slight extent only by the velocity with which the shell is passing through the air; and the other is that a stream of bullets has a very large parallelogram of effect. Whether the guns are to be large or small of course depends entirely on the facility with which the ammunition can be carried, because the question in all such cases is, how you can carry your ammunition more than how you can carry your gun. This is

more the case in the field than with ships, because on board a ship you have nothing to consider as to carrying the gun and very little as to the ammunition, but with troops the question is, who is to carry the ammunition? When you give me a gun that will fire 60 shots a minute, whether a breech-loader or a Gatling, I have to consider very closely how I can keep up that fire so as to be of any use. I object very much to the form of cartridge adopted here, for it is a recurrence to that most objectionable form, that compromise between the Daw and the pure metallic cartridge known as the Boxer, in which several metals are used, and galvanic action is to be feared, and the base cup is attached by a variety of means best known to the inventors, but all more or less objectionable. The effect is very much superior with the simple metal, and there is much more room for powder. I prefer the simple American cartridge for all kinds of ammunition. The foil was adopted by Mr. Daw when he gained the 500*l.* prize from Government, and it was very speedily followed by other persons, but as they had not the knowledge of practical work which he possessed, they added brown paper, and bees-wax, and varnish, and one thing and the other, till they made up the most desperate specimen of a cartridge that ever was got together by men who had neither practical skill nor inventive brains. With regard to the question of the facility with which this gun could be pointed and used, that is very largely a question of training. After all, each gun has its merits, and we must thank Mr. Hotchkiss for having taken us a little further in advance than Dr. Gatling had done. Whether Dr. Gatling will not turn the tables on him, and by-and-bye produce something better, is a great question for those who have to be shot at. I shall be very glad to find that we are still making advances in weapons of war; what we all believe must be the result of the perfection of weapons of war, namely, a universal peace; but I am quite sure the rivalry of inventors is not to be considered at all in an Institution like this. Let them each do the best they can, I presume they will take all the protection they can get from the law, and we shall then all benefit by their operations. I am always reluctant to see in an Institution which is devoted to scientific purposes, the discussion of an invention on any such grounds. The lesson we may very well learn from our American cousins is this, that they use machinery so largely in the production of every weapon, and in almost every other piece of machinery they turn out, down to a Waltham watch, and so surpass everything our skilled artizans can turn out in lightness, elegance, and adaptation of materials to their proper uses. Close consideration and liberal investment of capital precedes the manufacturer's manipulation, and the result is, when we see a piece of American workmanship of whatever kind, a chuck for a lathe, a pair of parallel pliers, which have never been seen in England before, a gun or a firearm of the smaller description, we are all struck with the beautiful adaptation of the means to the end. Here we have an instance of the same thing. In taking to pieces this gun, no one can fail to have remarked the extreme ease with which it was dismounted and put together again. There is great merit in that, for when we know that, whatever may happen, there is no great difficulty to be anticipated or time to be lost in taking the pieces apart and putting them together again, it gives great confidence in the gun. The lecturer spoke of a matter which I am very glad to hear about, when he referred to the material used in the construction of the gun. He says, that the sliding parts being made of gun-metal, it is impossible for them to rust; but we know the chlorine of the sea water creates another form of rust even on gun-metal, and it is important that all surfaces should be designed so as to meet the conditions which we must expect to have at sea at times. It is not always that you can keep guns in the largest ship perfectly free from salt water, in fact, from being under water half the time, and particularly so if we build ships as we are doing now, we must expect to pass a good deal of our lives in going through the water instead of over it, guns and all. Every inventor, therefore, who considers those questions closely, merits a very large share of approbation at the hands of seamen. The great evil is, that very few inventors will take the knowledge of seamen and make use of it; they give us something that they can use beautifully on shore, but which, when it comes to be used at sea, fails, because they have not considered these questions. I think Mr. Hotchkiss has done a great deal for us. He has given us a power of sighting and firing in a single hand. It is quite certain that the one man who is guiding and directing at the same time can

do much more than can be done by any machinery with a rolling ship, or by any combination of men, some of whom have to do one thing and some another. If the whole power is concentrated in the captain of the gun, more accurate work will be done and better results obtained in all cases.

Mr. NORDENFELDT: In reply to the question put to me by Lieutenant Armit, I may say it was not a 1½-inch plate that was fired at, but a ¾-inch. It was not penetrated by my 1-inch solid bullet weighing 7 ozs., and it was not penetrated by Mr. Hotchkiss' 1½-inch bullet weighing 16 ozs. They both struck at 300 yards range. Mr. Hotchkiss' shell made an indent of ·2 of an inch. We must not forget that system is one thing and calibre is another. The system of a projectile may be said to mean the difference between the solid bullet and the shell, which is extremely important. The lecturer has held forth the great advantage of shells, but I feel rather strongly in favour of solid bullets for naval use. Instead of his shells I would rather fall back upon a rapid-firing gun, firing solid bullets. I can hardly be expected to praise a revolving gun, because I do not like them; I can hardly be expected to praise a gun that fires single shots, because I think guns firing volleys are so much more powerful for naval use; but I am afraid of getting into a discussion as to other systems of guns than that of the lecturer, and that I do not mean to do. I think Mr. Hotchkiss has an excellent gun, but he has failed in one or two very important points, even leaving out the question of single shots *versus* volleys at sea. The ballistical condition of a 1½-inch gun ought to be about 2 lbs. bullet, and 1,600 or 1,700 feet velocity. Mr. Hotchkiss has been persuaded to go away from his original idea by cutting short his barrels, and diminishing the power of penetration of the 16-oz. bullet to the same that I have with my 7-oz. bullet, and thereby I consider destroying the greatest advantages which he otherwise would have had with the gun. A smaller calibre of gun is not allowed by the International Convention to fire shells, consequently in a 1½-inch bore you can have shells which you cannot have in a smaller bore. But I speak about the great advantage of machine-guns, not only as against torpedo-boats, but in general use, and a shell of this calibre, and with Mr. Hotchkiss' low penetrative power against a plate at a short angle, is utterly useless. A solid bullet is not. Mr. Hotchkiss has also steel pointed bullets; he admits the fact that solid bullets have great advantage for certain special purposes, but when he has a solid bullet of 1½-inch bore he ought to have a bullet twice its weight, and of three times its penetrative power. I cannot help thinking if you have the same penetration with the 7-oz. bullet as you have with the 16-oz., and if you can fire 7-oz. bullets four or five times more quickly, there is a distinct advantage in the smaller calibre, admitting of course that when Mr. Hotchkiss comes to his longer barrel, he is getting much nearer perfection than in the sea gun as now exhibited. As I said, system and calibre are entirely different. His revolving system I do not like because he fires single shots, and because if one barrel gets damaged the gun becomes useless. In his gun the laying arrangement looks very convenient, and is very "taking," if I may use the word. It strikes people as excessively convenient, but it is really far from convenient. It is extremely difficult to lay from the shoulder with accuracy and after each single shot, a gun fixed on a pivot, like the one before us. I do not like to speak about what we have done, because Mr. Hotchkiss and I are now pitted against one another at Portsmouth, and we will talk it over in a month or two, but I beg to be allowed to refer to the trials in Denmark which he mentioned in the lecture that I was thoroughly beaten, and so I was apparently for the very simple fact that the clever Danes fired my gun for accuracy at sea at ranges up to 1,200 yards without having my sights graduated, and without the slightest idea what elevation was required for it, whereas they had checked the elevation on the Hotchkiss gun and adjusted the sights.

Dr. GATLING: I am not in the habit of speaking in public. I merely wish to say this: in 1862, eighteen years ago, I first conceived the idea of the machine-gun, and I think I may say with safety I was the first who ever made a gun that loaded metallic cartridges automatically into the chambers of the barrels, and fired them continuously as you are aware the Gatling gun does. I see in the gun before me, as has been observed by several speakers, the very striking features of the Gatling gun, though it is not a Gatling gun in all its details; it is also a gun of larger calibre than the Gatling guns have been made heretofore. I believe that there will be need of

machine-guns of small and large calibres, and I would say in connection with this detail, that the Gatling gun admits of calibres of any size; it is simply a question of weight of metal. The Gatling, being the first of its kind, was ahead, if I may say so, of the ammunition, for even in America no one could make ammunition that was perfect, and I can say with safety that the Gatling gun has fired more worthless ammunition away than perhaps any gun in the world, and it had to take the discredit of all the bad ammunition that was made years ago. It was, however, the best that we could do. They did not know in America how to anneal the copper, and they did not know that certain kinds of copper were better than other kinds of copper. One of the little secrets they have in America is this: the copper "mined pure," in the Lake Superior district, having no foreign substance mixed with it, is of much greater strength and ductility than ordinary coppers, and its use is one of the secrets of the success of the cartridge makers in America. Another is, that they have learned to anneal the copper, and not to burn or destroy the material. I have seen cartridges made so perfectly that there is no trouble now. The day of bad cartridges in America has passed, unless now and then they use up an old lot that were rejected years ago. On one occasion I was invited to a trial of a Gatling gun, which the Navy had purchased, at Fort Maddison. They fired 100,000 rounds without a hitch or any interruption in the mechanism, 64,000 being fired continuously in the presence of a large number of Officers of the Army and Navy without their wiping the barrels out or stopping to clean the gun. That is an ordeal such as, in my judgment, no other gun has been put to. In Her Majesty's service they have not improved Gatlings, for the guns in the English service are all fed on the side, whereas the feed should be right in the centre. You will pardon me if I do not desire to fire the Gatling gun with the Boxer ammunition. That was no doubt good in its day, but it is not the best ammunition now. The solid-drawn case is the cartridge adopted by all the leading nations in the world save and except England, and the day is coming when that Boxer cartridge unquestionably will become obsolete. Machine-guns may be of different calibres. A light gun that you could pick up and move about quickly to any postion, and place it anywhere, is what is much desired. For instance, I have a little Gatling gun weighing 105 lbs. that I would fire against any gun that Mr. Hotchkiss can produce at a thousand or twelve hundred yards ranges, and beat him in the number of hits. Furthermore, my solid bullets, made of hardened lead, will give more penetration than the fragments from his shell. I should like to have a friendly contest with him upon the subject, but I will use the metallic cartridge. With that I can fire a thousand rounds a minute when the men understand their work, and there will be no interruption. I say, however, if the Gatling gun could not be made of larger calibre, Mr. Hotchkiss would have the field entirely for torpedo service, because it is absolutely necessary to have larger calibres for sinking torpedo-boats. There is, however, no trouble in making the Gatling gun of any size. I am now constructing some Gatlings of large calibre, and I may also state, for the information of gentlemen present, that I have a particular gun, not embodying the principle of the original Gatling, which I intend to bring out very soon. This gun I think will fire missiles of more than a pound weight, and will do the work of the Hotchkiss gun, or the large Gatling, if you please, and this new type of gun will not weigh so much, nor will it be so expensive in its construction as is the case in existing systems of machine guns.

Major FRASER, R.E.: I should like to ask what evidence there is that continuous rotating motion in a machine-gun causes a special dispersion of the cartridge. Is there any experimental evidence of that? My reason for asking the question is that the other day I saw a 0·45″ Gatling gun tried, and at a range of 3,100 yards 50 per cent. of the bullets fell in a width of 7·6 yards. That seems to show that the tangential motion due to the barrels does not cause any appreciable dispersion.

Mr. KOERNER, in reply, said: As to a similarity between this gun and the Gatling, the Gatling gun has a separate mechanism for each barrel, whilst this gun has one set of mechanism for all the barrels; that is one difference. Then, in the Gatling gun, the Nordenfeldt, and most other machine-guns, the cartridge bears on some part of the mechanism, generally the lock which carries the extractor, the spring and the firing pin or whatever is necessary to work the gun, and this lock has to sustain the continual shock of discharge; but in this gun the cartridge itself stands during the

time it is being fired against a solid mass of iron. We believe that that gives greater safety than is obtained in other guns in which the firing takes place on the lock, and which therefore has to support the shock of the discharge. A second point was raised as to what would be the result if, for instance, the head of a cartridge was torn off. Should a cartridge head tear off, and the case be left in the barrel, by opening the breech you can push the ramrod completely through the barrel and clear it in a moment. Should such an accident arise in the Gatling it is always necessary to take out a special lock, and whilst you are taking out the lock you can just as well open the breech door and run the rammer through to clear the barrel. As to the parallelism of the barrels. In this gun, as in the Gatling, they are all parallel to each other as far as they can be brought, of course not mathematically so. And when I spoke of the particular characteristics of the gun, and said that by the barrel standing still when firing we suppressed the tangential motion of the projectiles, I did not mean scattering motion, because if the barrels are rotated with equal speed in the Gatling, the deviation of the shots caused by this tangential motion would be about equal for each shot; so that I do not put this as a particular advantage of this gun, I only put it as a particular feature, supposing in any case it should scatter them, there would be no other difficulty about it, but if the Gatling gun is rotated by jerks, it may give a slight irregular deviation to the shots. With regard to the superiority of bullets over the shell for sweeping the decks of a ship, that is a matter of opinion. We imagine that the explosions of the shells and the enormous amount of fragments flying about, the smoke, flash, and everything will have a greater demoralizing effect on the men employed on deck than bullets would have; but certainly bullets can do a great amount of damage too. Another point was as to the quantity of ammunition to be transported to get similar effects to those of a bullet gun. It is certain that we do not require the same weight of ammunition, that has been tried very often. For instance, I read in the *Times* that for a Nordenfeldt gun in the English service, the dotation of ammunition is 8,000 rounds for each gun on board a vessel, whilst the dotation in the French Navy for the Hotchkiss is only 1,000. Commander Brown asked what would be the effect if a cartridge was to explode before it was struck? That is a thing which is hardly possible to occur. By reason of the construction of the gun, the cartridge is not pushed home into the barrel rapidly. This is the only machine-gun in which it is done in this manner. It goes in quickly at first, but afterwards there is an inclined plane that carries it forward gradually and without shock, until it is "home" in the chamber.

Dr. GATLING: That is the same kind of movement that is performed in the Gatling; the gradual spiral movement.

Mr. KOERNER: It is done in a similar manner. Supposing it did explode, the breech at the bottom between the barrels is open so that the gas simply comes out at the bottom, and besides, the man firing the gun has the protection of this heavy breech. Even if a barrel burst, he would be protected, because the barrel that burst would be the firing barrel at the bottom, and there is hardly any possibility that the man could be injured. On one occasion, before we used Whitworth steel, a barrel burst when I was firing the gun. Four or five men were around it; one was feeding it, and Mr. Hotchkiss and other gentlemen were looking on. The bottom barrel burst, but it absolutely did no injury to anybody. It burst downwards. The other barrels are on the top, and the breech is behind, so that in this manner the men were protected to a great extent.

Admiral Sir COOPER KEY: I do not think Captain Brown thought of the men being damaged only, but that, when one cartridge exploded prematurely, the chances are some of the others would explode also, and that would damage the gun.

Mr. KOERNER: It depends on where it explodes. If it was to explode in the receiver, you would have the chance of the others which were on the top exploding; but the further they explode down to the bottom the less danger there is, and when it is on the bottom it is impossible to do any damage, because the cartridge is standing against the breech, and this is closed. The cartridge is not constructed on the Boxer plan; there is no paper in it. When Mr. Hotchkiss first commenced making the revolving cannon, he used a solid-drawn cartridge; but it is absolutely impossible to manufacture solid-drawn cartridges in which, now and then, a head

will not come off; from a flaw in the metal, or something, you will have a certain percentage in which the heads break off. In a large cartridge like this, if the head breaks off, there is a large escape of gas, and a great deal of damage may be done. The second cartridge was made of tin, but they had difficulties with that, and at last they came to make these rolled brass cartridges. There is no paper of any kind; it is a spirally rolled case, with reinforcing cups and an iron head, all riveted together. With these cartridges a head never comes off. During all the extensive trials that have been made with this gun, during the last two or three years, and all the trials made by the different Governments, there has never been one single account of a head coming off or a cartridge bursting. This makes absolutely the safest cartridge. Solid-drawn cartridges are liable to stick in the gun, which makes it difficult to extract them. This, being spirally rolled, it can open out a little, by the pressure of the powder, and mould itself to the chamber, but it goes back again; you can take out every cartridge after it has been fired, even the largest ones, with the finger-nails. In most cases, you will find a large solid-drawn cartridge will stick; it is only in the smaller ones that there is not so much difficulty in that respect.

Dr. GATLING: With regard to that matter, in the large class of ammunition used for the inch Gatling, at first I was troubled by the head coming off, even when they were made of solid material, but by using solder in the base of the cartridge, that difficulty was removed, and since that time hundreds of thousands of cartridges have been fired and never a head come off. There is no trouble about the extraction. I would say, as regards the trials of the Gatlings made in France, that the number of hits was less with the Gatling guns and the same proportion of ammunition, but I wish to say that the guns used were of the oldest type of Gatling gun. I do not know who pointed the gun, or anything about it; but I will only say the French bought some old type Gatlings, I think in 1869, and I believe it was these guns that were used. Such results could not have occurred with the improved Gatling gun.

Mr. KOERNER: Mr. Nordenfeldt spoke as to our reasons for cutting down the ballistical power of the 1½-inch gun. That was necessary, because we first constructed this particular model for the French Navy, and the naval artillerists made up their minds that they would have a gun that should not exceed 200 kilometres in weight; it should be possible to put it in the tops; it should be short, have no projecting parts to it, and, besides that, there was the question of the recoil. In a gun limited to about 400 lbs. weight, if you fire large charges and large projectiles with high velocities, the recoil on the man would be so violent that he would not be able to withstand it, and for that reason we were obliged to cut down its power. But it gave ballistical results better than were even asked for by the French Navy. In the 1½-inch gun, weighing 700 instead of 400 lbs., you have much more power. Mr. Nordenfeldt said that in Denmark they made a special sight for the gun used in the experiments; but that is not the case. The identical French sight was used, and the captain of the gun simply corrected his fire by seeing where the previous shot struck.

The CHAIRMAN: It only remains for me to thank Mr. Koerner for the full and exhaustive explanation of the gun which he has been good enough to give to the meeting. I think our thanks are also due to the other inventors who have been good enough to contribute so much to our information on general points connected with the machine-gun. I understand that a trial is shortly to be commenced at Portsmouth, which will, no doubt, develop the merits of both guns, and particularly of this new invention. I am sure it can only be the wish of those who are to use them that the palm shall be awarded to the most worthy.

Wednesday, April 21, 1880.

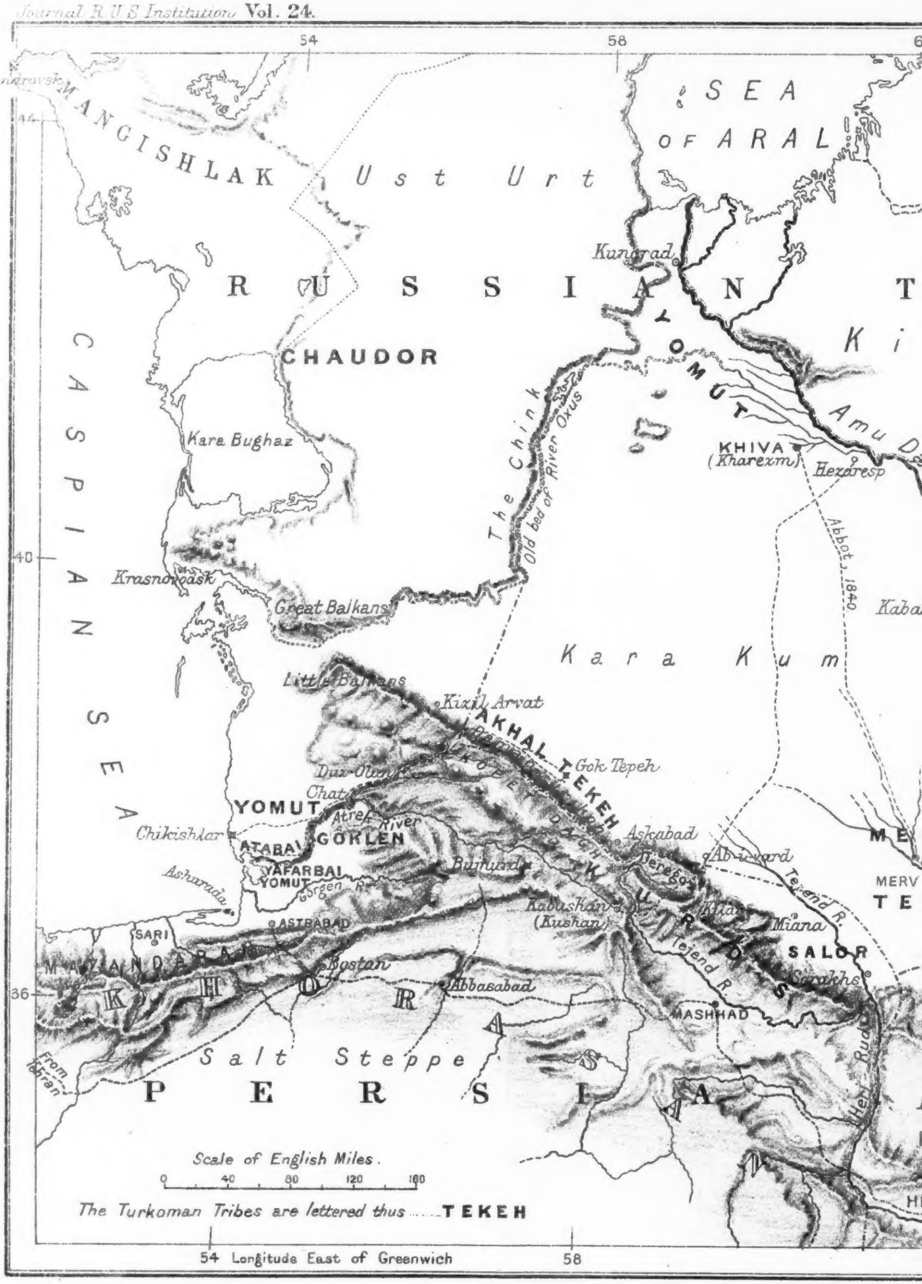
MAJOR-GENERAL SIR HENRY C. RAWLINSON, K.C.B., F.R.S., &c., &c., in the Chair.

THE PAST AND THE FUTURE OF THE TURKOMANS.

By PROFESSOR ARMINIUS VAMBÉRY.

The CHAIRMAN: My Lords, Ladies, and Gentlemen,—It can hardly be necessary for me to deliver a formal address in introducing to this meeting a gentleman of such world-wide celebrity as Professor Arminius Vambéry. Professor Vambéry made a most remarkable journey some years ago through Central Asia, in the disguise of a dervish, carrying, according to Eastern phraseology, his life in his hand, and visiting on that occasion many celebrated cities, such as Khiva, Bokhara, Samarkand, and Herat, which were then very little known to Europeans, but which since have become bywords in political history and subjects of great and general interest. It is only due also to M. Vambéry that I should say that since the time when by his journey he was suddenly placed in the first rank of travellers, he has year by year confirmed his hold upon the respect and gratitude of Europe, not only by the zeal and ability with which he has prosecuted researches into the history and literature of Central Asia, but also by his constant and earnest endeavours to promote in that region the interests of commerce, of civilization, and of general progress. With regard to the particular subject on which Professor Vambéry will address you to-day—the Past and Future of the Turkomans—I may safely say that he is not only the best, but almost the only authority: at least I am not aware of any other European who has lived amongst these formidable children of the desert as one of themselves, and who has thus not only gained a general acquaintance with the outlines of their character and pursuits, but has also been able to acquire an insight into their inner life, and become familiar with their thoughts and feelings and social habits, so as to place him in a position to forecast with some confidence the *rôle* which they will have to play in the future history of the East. There is only one other observation I wish to make before inviting Professor Vambéry to address you, and that is, to remind the Members and visitors who are here present, that the United Service Institution is not an arena for political controversy; but that our functions here are limited to the discussion of professional subjects and matters of general interest. It is quite true that it would be impossible to eliminate political considerations altogether from the discussion of such a subject as the Turkomans, because it is their geographical position—placed as they are as a "buffer" between the Caspian and the Indian frontier—which gives them their particular interest in the eyes of Englishmen. But if any of you have formed decided opinions on the subject of these tribes, I would beg at any rate that such opinions may be stated temperately, and with moderation and fairness, the speakers avoiding anything like party feeling or political bias, but rather showing that our only desire is to acquire sound information on an important and interesting subject. I now invite M. Vambéry to address the meeting.

Professor VAMBÉRY: IN a lecture upon the Turkomans, we may dispense with the description of the manners and habits of that people, which I touched upon some sixteen years ago, and which have been lately so variously commented upon in Periodicals as well as in the Daily Press. We shall therefore give preference rather to a general sketch of the historical development and of the ethnical peculiarities of this portion of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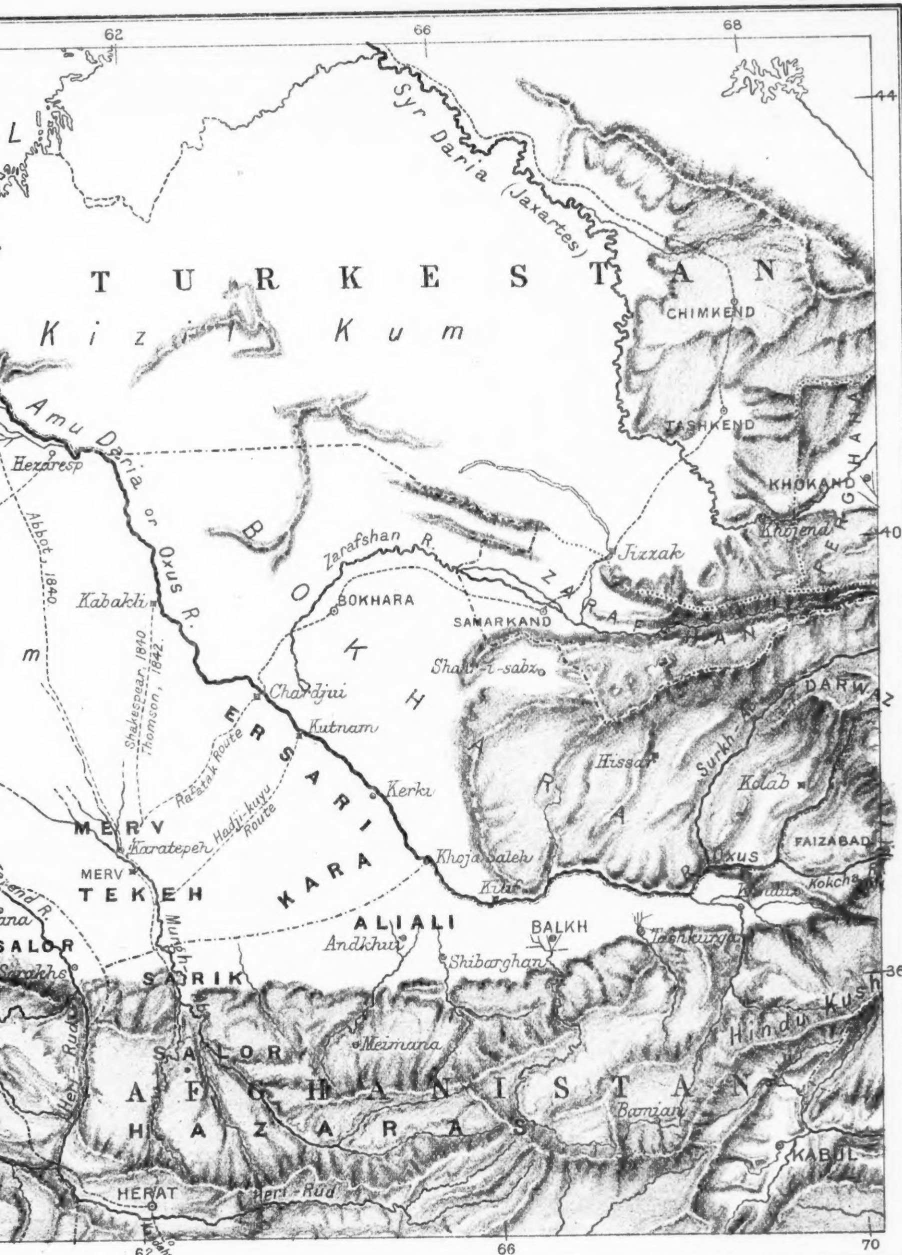

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the Turkish race, putting particular stress upon the chances a conqueror may have in his attack upon this people, and consider at the same time the means by which a future collision between the two European rival Powers may be avoided in this part of the Asiatic world.

There is no doubt that the Turkomans belong to that branch of the Turkish race which first separated from the bulk of the natives known to have lived in prehistoric times in the Altai and in the upper regions of the Yenissei and of the Irtish, and who started the first in the search of a new home on the plains of south-western Asia. This evidently took place long before the beginning of the Christian era; possibly at the same time that the ancestors of the modern Bashkirs, Chuvashes, and Nogais appeared on the banks of the Ural, of the Dnieper, and of the Volga; and whilst these latter ones only touched in their migration the northern region of the Caspian Sea, the Turkomans have spread gradually partly southwards, partly eastwards in the great steppes and deserts which extend on the eastern shores of the said sea towards the outlying ranges of the Hindu Kush. Here they lived in remote antiquity, and here they were met with by the outposts of the Roman and Greek armies; nay, I go even further in assuming that the Parthians were simply the ancestors of the present Yomuts and Tekkes, for the home of the ancient Parthians, namely, Dehistan (so called from the Dahae, a Parthian tribe, as we learn from Sir Henry Rawlinson), consisted of the region between the Atrek and the Balkan hills, at present and as far as historical record reaches, always the abode of the Turkomans. Of course the thick veil of obscurity hanging over this part of ancient Asia does not permit us to penetrate into geographical and ethnical details; for even the notions which have been handed down to us by mediæval writers on the supposed ancestors of the Turkomans are so confused, that it would be almost impossible to form a definite idea upon the relationship of the Ghuzz, and certain present fractions of the nomads of the Hyrcanian steppe. There cannot be any doubt, however, as to the identity of the name *Ghuzz* and *Turkoman*, and whether the Turkish people, known under the former name, constituted only one single tribe or branch, we may nevertheless assume that the Turkish nomads who caused so much trouble to the Samanides, the Deïlemites, and Ghaznevides, were, strictly speaking, Turkomans, who, coming down from the north-eastern shores of the Caspian, from the Mangishlak of to-day, had already endeavoured at that time to get possession of that fertile tract of country which, lying to the north of Persia along the Kopet mountains of to-day, richly irrigated, must have early attracted the cupidity of the naked children of the desert. The contest which ensued between the last owners and the settled Iranians was a protracted one, but in the end the barbarians got the upper hand, and towards the end of the middle ages, places formerly flourishing in the Khorasan mountains were mere ruins, and haunted by the different tribes and branches of Turkomans bent upon war and pillage, partly in the adjacent country, partly amongst themselves.

In the course of these continual fights and struggles, we see but a few fractions of the Turkoman nation emerge into individual noto-

riety; for example, the Salor and Sarik, during the conquest of the Arabs, and, strange to say, in the very place which they now occupy. A few centuries later we meet the Kara and Alieli Turkomans in a successful engagement with Sultan Sandjar around Andkhui and Meimana, in the very place where the remnants of these once mighty tribes are actually to be found. Again, a few centuries later the families of Ak-koyun and Kara-koyun (*i.e.*, white sheep and black sheep) appeared upon the arena of historical events, spreading their influence as far as Asia Minor—a fact which still lives in the memory of the present Turkomans, for they say, "a portion of our "brethren has gone to the distant west." By this they mean the Yürüks and the Osmanlis, who are, indeed, their nearest relatives, as may be judged from the comparative study of both languages, as well as by historical evidence; for the Seldjukians, who came forward in the eleventh century from the Lower Yaxartes, were in fact but the most northerly fraction of the Turkoman people, and the nucleus of the Ottoman nation is, as generally known, an offspring of the Seldjukians. It would, indeed, lead us too far, if we were to enter into the historical details of the much agitated past of this people. Suffice to say, that notwithstanding their unbounded lust for war, and their unrestrained adventurous character, which originates to a great extent in the naked and barren soil of their steppes, they never rose to an united action, but were, as far as historical record goes, separated amongst themselves by continual feuds, and subjected to frequent change of abode, as well as to a constant fluctuation of their numerical conditions. According to reliable information gathered from a manuscript, which I am about to publish, the Ada district of the Mangishlak Peninsula was towards the end of the fifteenth century entirely in the possession of the Turkomans, a place which is now almost exclusively in the hands of the Kasaks, and in the vicinity of which only the small tribes of Chaudor and Imraili linger in a miserable existence. Thus for example the Ersari Turkomans, which constitute to-day the half-settled population of the left bank of the Oxus between Kerki and Chardjui, are reported by Abulgazi to have lived in the sixteenth century near the Balkan; and whilst the same author gives to the Tekkes (the most numerous tribes of to-day) only a secondary importance, he mentions the tribes of Arabdji, Ali, and Khizr, of which now only small traces are to be found.

From the foregoing allusions to the early history of the Turkomans, it will become apparent that the life they led hitherto is distinctly different from the life of other nomadic people, such as the Kirghiz-Kasaks, the Kara-Kirghiz, and Karakalpaks, who, whilst retaining all the vicissitudes of nomadic existence, were unable to preserve the striking features of their national individuality, owing to the frequent intermixture of Mongolian and various South Siberian Turkish elements, not less also to the early contact into which they came with the Russians. The Turkoman, on the contrary, has remained always in a comparative seclusion from his nearest relatives, and this accounts mainly for his quality of an indomitable warrior, of

an excellent horseman, and of an indefatigable adventurer, of which he was always famous in the history of Asia. Ask the townspeople of Central Asia, of Afghanistan, of Persia, nay, even the nomad of these countries, and they will readily acknowledge the military superiority of the Turkoman, who may be abused as a naked barbarian and robber, but to whom nobody will deny valour, intrepidity, and rare facility to endure hardships. And such is indeed the fact, as far as I could convince myself by personal experience. Having spent several weeks amongst the Yomuts, I was astonished at the hardy, warlike character, not only of young men between twenty and thirty, but also of the similar quality to be met with in boys from ten to fifteen, and of the aged, sometimes sixty or seventy years old. There exist, as I said in my previous writings, two different classes—the Charva, *i.e.*, the cattle breeder, and the Chomru, who are addicted to industrial and mercantile engagements. As a rule, it is the Charva which furnishes the most unruly element of the Turkoman people. In the solitude of pastoral life human fancy is easily carried away towards the most daring adventures; and as the exploits of famous heroes and warriors are always looked upon as the greatest human perfection, we must take it for a very natural consequence, that out of five nomadic youngsters, three will certainly long for an opportunity to show their personal valour, and to earn glory and wealth by an inroad into a hostile country. This is and was the origin of the Alamans, or marauding parties, which formerly visited all the adjacent countries, and which infested two or three centuries ago by preference the northern part of Persia, behaving in the same way as the ancestors of civilized Europe behaved in the beginning of the middle ages; I mean to say carrying away property and slaves for sale in the markets of Central Asia, becoming thereby the terror of the settled population of Mazandaran, Khorasan, nay, even of Sistan, where they rarely met with serious resistance, and very often succeeded in overawing their enemy, though five or ten times more numerous.

If we investigate the reasons of this extraordinary superiority of the Turkomans, we shall find, firstly, those conditions which difference of race and of daily occupation have produced, wherever nomads are in conterminous neighbourhood with a settled and civilized population, conditions which have been in most cases detrimental to the latter ones, so long as an established, firm rule cannot afford the necessary shelter so sadly wanting now in Persia. Secondly, we must take into consideration the personal valour and soldier-like qualities by which the Turkomans have always distinguished themselves amongst the different peoples of Central Asia. Unlike the Kasaks, their more numerous relatives in the north, the Turkomans have not only retained that pristine spirit by which the Turanian hordes of antiquity excelled their enemies, but also many habits and customs of the old Shaman religion, which are so met with either among the Altais or the Chuvashes. Their tactics are strictly the same as those which Priscus described as those of the Huns, or Leo the Emperor as those of the ancient Magyars; and such is their insatiable lust after warlike undertakings, that any elder or more experienced nomad has only to

send a word to the branches and families known for enterprising men and for good horses, when after a few days, a respectable number of knights errant will obey his call by presenting themselves at the appointed meeting place. Here the elder, called Sirdar, *i.e.*, Chieftain, will muster his followers with gloomy, sulky regards; he will upbraid certain defects in the arms, in the straps, add a few rather caustic exhortations, and after taking the usual Fatiha, *i.e.*, blessing, from an influential Molla, the party will proceed at once; and on they go, in blind obedience to their leader, resting in the day-time, lying in ambush or marching during the night, and attacking mostly at the dawn, with an impetuosity which will tax the strength even of a regular army, but which an Asiatic soldier can hardly withstand. Thirdly, it is the comparative inaccessibility of the steppes by which the great bulk of the Turkomans has been preserved from the sweeping events of the great historical revolution, and by which they were less exposed to an outer contact than the rest of their nomadic brethren in the north. By the light of this theory we see, for example, such tribes as inhabited the borders of the steppe between Persia and Khiva more frequently assailed and weakened than those who lived under the shelter of deep sands and waterless tracts. In illustration of the said theory, we may quote the Chaudors and Imraili in the north-west of Khiva, the Yomuts and the Göklengs, in the vicinity of Persia, further, the Ersaris, on the left bank of the Oxus, finally, the Sariks and the Salors, in the neighbourhood of Herat, who, centuries ago unable to augment in numbers, have remained almost stationary, whilst the Tekkes, sheltered by the Kara-Kum on three sides, have during the lapse of 150 years increased to such numerical strength that they constitute to-day nearly the half of the total number of the whole nation. It is this natural stronghold which has proved also quite recently their safeguard against the advancing Russian columns; for in spite of the seeming vicinity of the Tekke territory to Chekishlar or to Krasnovodsk, we must read the details of the most fatiguing march on the first 110 miles through the sands and arid steppe, from the sea shore to the first Tekke tents, to get a proper idea of the enormous difficulties with which the present home of the Tekkes can be reached even on this more accessible part. Notwithstanding all exertions, and the astounding perseverance of the Russian soldier, the invading army could scarcely make 12 or 15 miles a day, and this only by losing nine-tenths of the camels, and by totally exhausting the soldiers. And yet this is regarded as one of the more accessible routes to the Tekke country; for those leading from the north are regarded as far more difficult, and known as fraught with all kinds of dangers even for the native armies of Central Asia. An army starting from Khiva in a southern direction has only the chance of the usual caravan road known under the name of Kabakli, a little place on the edge of the Khivan oasis, from which Merv is 180 miles distant, a route by which Shakespear, and Thomson went to Khiva, and which may be found practicable for an army only early in the spring or during the winter, for the said 180 miles go across the desert, provided at long intervals with wells of bad water.

During the middle ages, as well as in modern times, Merv was connected with Khiva only by this line; and every deviation from this highway to the south upon the shorter route across the Kara-Kum has always ended in disaster; thus, for example, the experiment of Nadir, and the march of the Uzbegs under Medemin, who almost entirely perished in the sands. The way from Hezaresp to Deregöz, which is decidedly the shortest from Khiva to the Tekke territory, is looked upon as a most hazardous undertaking, even by trading caravans, and the very scarce traffic on that line is kept up by poor, daring merchants under the risk of life and property. It is therefore the only route, *viâ* Tchardjui, by which Merv or the country of the Tekkes can be reached with a certain amount of safety, although not without hardships for an army, from the north. Between the existing three different routes, that of Rafatak (the word signifies an egg-shell) is said to be the easiest, and next to this, that of Hadji-kuyu (the pilgrims' well). Both have served from immemorial times as the link of connection between Khorasian and Bokhara, and will be probably used also by the Russians in an eventual march upon Merv from Bokhara.

I suppose, Gentlemen, that these faint outlines will convince you of the inaccessibility of that portion of the steppe which is inhabited by the Tekkes, as well as of the greater independence which the Turkomans as a nation have enjoyed, if compared with the political conditions of their nomadic brethren in the north and in the east; and if I add the excellent breed of horses (for which they were known already in the middle ages), you will easily find an explanation for the impunity and audacity with which they always attacked the neighbouring countries. Partially vanquished by great conquerors, such as Djenghiz, Timur, and Nadir, they were never entirely subdued, but have, on the contrary, more than once frustrated the ambitious schemes of such renowned princes as Sheibani, Shah Ismail, and Abdullah Khan. Whilst incessantly fighting against Persia, but, fortunately for the country, only as single fractions, and never as a compact body, they constantly refused allegiance to the Central Asian rulers. Khiva has tried for centuries to bring these hardy children of the steppes under her sway; and whilst Bokhara vainly gave up this hopeless task towards the end of the last century, we see Iran alone clinging to her claims, but unsuccessfully, for in almost all her recent engagements, the Persians have been worsted, nay, ignominiously beaten, by the Yomuts and Tekke Turkomans.

Well, I dare say that this state of affairs would have remained for centuries to come, if the restlessly advancing outposts of western civilization had not knocked quite recently at the sandgates of the Turkoman steppes, the shrill echo of which blow resounded far into the interior, filling the breasts even of these hardy warriors, if not with terror, certainly with dismay and uneasiness. The great social and political changes which the Russian conquests produced in Central Asia, had very early thrown their shadows on the banks of Tejend, of the Atrek, and of the Görgen. The Turkomans had a strong presentiment of the approaching danger, and of the evil days

in store for them, but we must be just in saying that they were scrupulously anxious not to accelerate the catastrophe, and that they took all possible care to avoid any collision with the Russians. They withstood not only the pressing demands of co-operation against Russia, directed to them by Bokhara and Khiva, but refused even their assistance to the Yomuts in the war with General Golovatchoff, a policy which was as detrimental for the whole nation as it was advantageous for the Russians, for had the Tekkes joined their fighting brethren at Kizil Takir, I daresay not a single Russian would have escaped destruction, and the defeat through the Turkomans, reacting upon the Uzbegs, would have had a most disastrous result for the whole Russian Army. A similar abstention was exhibited by the Tekkes and Southern Yomuts during the subsequent years after the Khiva campaign, and it was the much more astonishing to hear the Russians continually speak of Tekke hostilities, and particularly of their being a great hindrance to the establishment of a trade route between Khiva and Krasnovodsk. It is certainly not for the first time that Russia has put forward her schemes of political aggression under the garb of humanitarian or commercial purposes, but the pretext used in her aspirations on the Turkoman steppe was of such a wild character, that it could hardly find credit with anyone, however superficially acquainted with the past of these regions. History records well of a commercial route from Kharezm across the Manghishlak Peninsula to Astrakhan, as well as of a caravan route, said to have existed in remote antiquity, between Northern Iran and the ancient Djorjania, but, strange to say, we are at a loss to discover even the slightest trace of a trading route between Kharezm and the Balkan Bay, a route almost impossible in consequence of insurmountable natural obstacles, and which Russia nevertheless was most anxious to open apparently for the benefit of commerce, but in reality to provoke a quarrel with the Tekke Turkomans, who, as the mightiest fraction of the Cis-Oxanian nomads, were looked upon as the chief barrier in the planned movement on the left bank of the Oxus, on this new ground of Russian ambition, where from Darwaz to Chardjui the whole terrain having been prepared and levelled, the still remaining obstacle had likewise to be removed.

It was in the pursuance of this end that the position at Tchekishlar, a bare naked spot without any signification, had to be secured; that the Atabai and Jafarbai, the two chief branches of the Yomut, had to be subdued, and that during the last six or seven years reconnoitring parties were continually sent in an eastern direction from Tchekishlar, partly to investigate the country, partly to facilitate the means of collision with the Tekkes, an object in view which was very easily attained, leading at first to some minor engagements, and finally to the so-called chastising expedition, which we witnessed quite recently, and which ended, as we all know, most disastrously for the invading Russians. In the presence of so many distinguished military authorities that I have the honour to count amongst my listeners, it would be certainly a most hazardous undertaking to come forward as a military

critic with regard to the mistakes committed by the Russians. In my quality of a philologer I must abstain from entering the field of discussion allotted to the gallant sons of Mars, but as one who knows the Turkomans and their desert from personal observation, I venture to ascribe the failure of the Russians to the following circumstances:—

(1.) Their having chosen the worst season for a march across the sand, for they started at midsummer, when even Turkomans themselves most carefully abstain from entering the waterless track through the deep sands, when, besides thirst and heat, the horrible plague of flies, gadflies, and gnats, make motion either in the daytime or at night most troublesome, if not impossible.

(2.) Their ignorance of the territorial condition of the country they invaded, in which, notwithstanding the former reconnoitring parties, they always roamed in the dark, not knowing in the morning at what station they would be at noon or in the evening.

(3.) Their insufficient acquaintance with the character of the Turkomans in general, and particularly with the military qualities of the Tekke tribe. In spite of the brilliant defence shown by the Yomuts in Khiva, who are semi-nomads and inferior to the Tekkes, the Russians seem to have underrated the personal valour of their adversary by attacking them with a comparative small force, for, admitting that the whole expedition numbered 20,000 men, it is no doubt that the column, which penetrated as far to Göktepe, greatly diminished by garrisons left on the road, and not less by maladies, scarcely consisted of more than of 3,000 to 4,000 combatants, and were easily outmatched by the two or three times larger Turkoman army. Further, it is quite apparent that General Lomakin has shown an unjustifiable confidence in the Turkoman auxiliaries, in the company of which he marched to the Akhal country. Whilst fully conceding the deep hatred which has always separated the Yomuts from the Tekkes, I cannot conceal the impression that the Yomut friendship was only feigned and their co-operation with the Russians only gained by force. This is proved by the continual escape of the camel-drivers in the midst of the sandy deserts, and by the disappearance of those Yomut horsemen employed either as scouts or for the defence of the provision trains.

Under the actual conditions, however, the causes of the Russian defeat are only of a secondary importance, for the undertaking, missed for the first time, will evidently be reassumed this next spring. The Russians must repair their loss as quickly as possible, for any negligence or delay in that direction would be equal to an entire loss of prestige and respect in the eyes of the Central Asiatics. Of these circumstances the Russians are fully aware, and we shall rather discuss here, firstly, the chances which await the northern conqueror in this contest; secondly, what are the benefits Russia may ultimately gain by that struggle; and thirdly, the means by which collision between the two great rivals may be averted in this part of the Asiatic world. Considering what we said in reference to the inaccessibility of the detached oasis-like home of the Tekkes, as well as of their superiority

to the rest of the Turkomans, it may be taken for certain that the Russians have entered upon the most difficult task they ever met with in their far-spread Asiatic conquests. The subjugation of the Yomuts and Tekkes can by no way be compared to the similar work in the steppes north of the Yaxartes, to the accomplishment of which nearly two centuries were necessary in spite of the undeniable fact that the Kirghiz-Kasaks were never such an indomitable warlike race as the Turkomans are. Of course the Russian Empire of bygone times was essentially different from that of present Russia; untiring efforts supported by military skill must in the end triumph over natural obstacles, as well as over the undaunted courage of irregular nomads. The work of former centuries may be now done in a few decades, and by entering the Turkoman country from two opposite directions, namely, from the sea shore and from the Oxus, and by spending blood and money, Russia will ultimately succeed in forcing these unruly elements under her sway, and in doing away with this barrier, as she has done in the Caucasus, on the Emba, and on the Amoor. In this respect I cannot give room to any illusions, nor can I practise self-deceit in believing nor in making others believe that the results of this undertaking may not be worth the cost and sacrifices. The Turkomans, if well led and well armed, can easily become the most splendid cavalry in the whole world, and if Russia remains only for a few decades the undisturbed master of the desert, she will certainly avail herself of this military material in the future encroachment upon the south. The presently acute differences of race and religion will in the course of time die away in the Hyrcanian desert, as they died away with Bashkirs, Transcaucasian Turks, and other Turanians fighting at present under the banner of the Czar, and who, helping to enlarge the gigantic army of that despotic Empire, unconsciously form the leaven of new aggrandizements and tighten their own fetters. This was the case almost everywhere with rising Powers; one would almost say that it is the natural law, in consequence of which the rolling avalanche acquires strength and speed through the increase of steadily adhering new masses. And yet admitting all this, I do not see the impossibility of placing a barrier against the threatening danger, provided that both parties are sincerely bent upon the avoidance of a collision.

That the Turkomans cannot be allowed any longer to continue their present mode of living, by which they have become a real plague to the north of Persia, and have checked at the same time the peaceable intercourse between Iran and Turkestan, that must be obviously clear to anyone conversant with the conditions of the said countries. There is a remedy for that evil, and it depends only on Russia, whether she permits the application of it. We all of us know that the predatory character of the nomads does not originate exclusively in the barrenness of the deserts, but chiefly in the weakness and in the anarchy of the neighbouring settled countries. History furnishes evident proofs that the Russians on the Ural, on the Volga, and on the Caspian had pre-eminently to suffer from the inroads of the Kasaks and Turkomans at such periods when order and tranquillity were disturbed in the interior of their own country, and when the local authorities

were unable to defend them. The same we notice also in Persia, where the watchfulness and firm rule of a single Governor had more than once proved the best protection against the restless neighbours in the steppes. More enlightened rulers, such as Shah Abbas the Great, and Nadir, have gone even further by pushing their outposts in the form of military colonies to the border of the desert, a policy which brought the Georgians to Abbasabad, the Kurds to Kushan, and the Afghan colony to Karatepe, and which has operated also for a long time successfully. Well, I do not see why such measures should not produce to-day similar results, and why Persia, if sincerely supported, should not succeed again in establishing a certain amount of order beyond the Damon-i-Kah and in the valleys of the Kopet Dagh! Whilst fully considering the intense and implacable enmity between the Shiite Iranians and Sunnite Turkomans, I still nourish the hope that if the Shah be enabled to bring a certain degree of order in his Government, and to have a well drilled and a well commanded army, he would afford the only and undoubtedly the best means of solving the Turkoman difficulty. With the aid of strong garrisons posted at Merv, Miana, Askabad, Kizil-Arvat and Chat, the unruly Turkomans would be kept in order, and the feigned object of Russian aggression in this part of Central Asia would have been removed. In speaking of the support, whether moral or material, of which Persia is so sadly wanting, it would certainly recommend itself, that both European Powers interested in this part of Asia should act simultaneously, but I suppose everybody will agree with me, that the time for self-deceit has already passed away. There cannot be any further illusion as to the purely humanitarian intentions of Russia. We all know, that it is the decomposition and ruin, not the welfare or revival of the Mohammedan Governments, for which she is longing. Russia will never lend any well meant assistance to Persia; this duty is incumbent solely upon England, as upon that European Power, which, whilst anxiously shunning further territorial extension, is only bent upon securing her frontiers from outer attacks. In this case Persia may become a useful ally, provided she is willing to change her former policy of distrust and indecision. The childish diplomatizing of Mohammed Shah and of his foolish Vizier, Mirza Hadji Agasi, must give way to an enlightened and an upright policy. Nasredden Shah and Mirza Hussein Khan ought to know that the vital interests of Iran can be only guarded through a strict alliance with England, with that England which is sure to prove at the present, a better friend and a more efficacious ally than in former times, when British statesmen were not alive to the great part this country has to play in the East, where not only her national interests are at stake, but where she has to fulfil the noble duty of civilization and humanity.

Sir T. Douglas Forsyth, K.C.S.I., C.B.: Ladies and Gentlemen,—I did not expect to be called upon, but I shall be happy to make a few remarks. Of course I have not had so much acquaintance with the Turkomans as M. Vambéry, but I have some slight knowledge of them, because it so happened that at the time when the Russians were advancing on Khiva, I was spending the winter at Kashgar, with the Ameer Yakoob Beg. While I was there, an embassy from the Turkomans arrived,

to consult with Yakoob Beg as to the course which they should pursue. I see that M. Vambéry in his paper ascribes to the Turkomans the virtue of patience and abstention from hostilities against the Russians. I believe that a great deal of that abstention was due to the very wise counsel which was given to the embassy by Yakoob Beg. Of course the matter was discussed very fully, and I had the benefit of hearing what was going on. I am afraid they were not quite so peaceably inclined as M. Vambéry supposes. They were only anxious to get a leader; and if they could have got one that could have united the different tribes of Turkomans, the Tekkes, Yomuts, and others, they fully hoped to be able to cope with the Russians. But Yakoob Beg counselled them not to attempt that, because he was fully convinced of the overpowering force of Russia; and he certainly himself would not put his finger into the fire, and he advised them to abstain. We used to receive accounts daily, I might almost say—certainly several times a week—of all that was going on in Khiva, and it was exceedingly interesting to hear their account of the state of the war with Russia. I used to get English newspapers giving the Russian version, and I need not say that the two accounts did not exactly correspond. But in course of conversation, I used to hear from the people in Kashgar their opinion of these Turkomans, and all that they told me thoroughly corresponds with what M. Vambéry has said in his paper, that they are amongst nomads *sui generis*, quite distinct from all other tribes. The Kirghiz, for instance, who get an unenviable notoriety sometimes, are not nearly so hardy nor so aggressive as the Turkomans. I have travelled a great deal among the Kirghiz, and seen them in their tents and their camps, and certainly they would be very uncomfortable people to meet when it comes to a fight, but they do not make slaves: they are a more pastoral people. They take part in any feuds which may be raging in the country round, but generally they are rather more peaceable. The accounts which I had of the Turkomans, however, were that they were perfectly indomitable, and it was certainly the opinion of Yakoob Beg that the Russians would have great difficulty before they subjugated them, if they ever did so. In fact the idea he gave me was very much like that which we have of mosquitoes—you may drive them away and kill as many as you like, but they come again, and perpetually sting you when you are asleep. Of course in the cause of humanity we must hope that an end will be put to the horrible practice of man stealing, but I think M. Vambéry has pointed out really a very sensible and proper solution of the difficulty. If the Persians on the one side, and the Russians on the other, guard their country so strongly that the Turkomans cannot come in and carry away their men and make them slaves, then the Turkoman occupation will cease. I join with M. Vambéry in the hope that they may become peaceable citizens, and be taken into the armies of Russia, but I do not think either he or I will see that day, because their independence is so rooted in them, that it will take a very long time to reduce them.

Captain Gill, R.E.: After the very interesting paper which we have had from Professor Vambéry, I cannot say much that is new or that I have not said before. I quite agree with all that Professor Vambéry has said, and I think the question of the conquest of the Turkomans is one which it will be very difficult for the Russians to solve, on account of the peculiar nature of the country in which they live. I think it is that character of the country that causes them to differ so much from the other nomads. It may be the desert life, so different from the life of nomads in pastoral regions, that causes them to be such a fierce and unconquerable people.

General Sir Frederic J. Goldsmid, K.C.S.I., C.B.: After the paper that M. Vambéry has read to-day, in which we all have been so much interested, I am afraid that anything I can say will be comparatively valueless. As to the so-called dangers of the route between Meshed and Teheran, in consequence of the Turkoman raids, to which reference has been made, I can testify from my own experience, that it is usual for travellers to go along that route with a large escort accompanied by a field-piece. What would be the practical uses of men or guns in the event of attack, I cannot speak to from any personal knowledge. Still, their mere passage to and fro shows that there exists a terror of the Turkomans through the country. My own opinion is that that terror is exaggerated, because I believe that, in nine journeys out of ten, no mischief happens. If, however, in the tenth journey ten or a dozen people are taken prisoners, we at once recognize a great evil

which precaution should be taken to avoid. I have no doubt that the Turkomans would form good cavalry for the Russians; but I firmly believe they would be a much more efficient body in our own hands. Unfortunately, the question herein involved touches on the region of politics: so that what I have said must be treated as incidental, or a sort of passing remark. With regard to the Persians, I take this opportunity of referring to a pamphlet which has been given to me only within the last day or two, and which is stated to be written by a Persian Minister. In it Persia, or the writer representing Persia, states her reason for not putting down the Turkomans to be because she is not able to get at Merv through the position she now occupies. From Mashhad to Merv the intervening desert renders communication difficult. The remedy which Persia proposes is, that she should hold Herat whence she could pass to Merv with ease, as there is a road between the two places easily traversed and much frequented. Under these circumstances she would be able to keep out the Turkomans: not so in her present condition. I suppose that it is for other Powers besides Persia to consider whether the measure contemplated could have effect. I merely mention it as the Persian reason for not stopping the Turkoman inroads. When travelling in the neighbourhood of Mashhad some years ago, I was asked by one or two of my road companions, "Why do you not stop the "Turkomans for us? You are the only people that could do so: we want your "help." I understood their meaning to be:—"We want your money." Were I to continue talking I should only perhaps be taking up your time with trivialities and wandering away from the main argument of the interesting lecture to which we have listened. It is only at the Chairman's call that I have risen at all, having come quite unprepared to throw light on the subject of Professor Vambéry's instructive paper.

Sir Charles Trevelyan, Bart., K.C.B.: Though I have never been in these countries, yet they have been the subject of my observation and study during my whole mature life, and I have been very intimate with those who have made them their study, and who have laid down their lives in the prosecution of that study. Professor Vambéry's lectures turn on a comparison between the Mohammedan *régime* and the Russian *régime*. Now, there is a verse in the Psalms which epitomises the Mohammedan *régime* in those countries—not in all Mohammedan countries—"The dark "places of the earth are full of the habitations of cruelty." I remember a characteristic circumstance related by Professor Vambéry himself with regard to these countries. A whole tribe fell under the displeasure of their Chief. They all had their eyes gouged out except one in fifty, who had one eye left that he might conduct the blind men home. But we need not have recourse to stories which might be thought apocryphal. Let us look at Bokhara, which was the hotbed of cruel fanaticism. I well remember the prolonged agony of the Stoddart and Conolly families. Arthur Conolly was one of my dearest friends. The black well, in which Colonel Stoddart was worn out with filth and vermin, and Arthur Conolly presenting his throat to the knife, saying he would never deny the name of Jesus, can never be forgotten by me. The slave trade which Professor Vambéry has so clearly laid before us, and which he has not attempted to palliate or extenuate, is far worse than the slave trade against which the last generation of our people rose in rebellion. The subjects of this slave trade are more sensitive, more intellectual, more cultivated, a superior people altogether to the degraded negroes, and yet this slave trade is still in active progress. Some may remember the praise which Sir Richmond Shakespear justly acquired for rescuing two or three hundred of these unhappy slaves, who were Russians, from the great slave mart at Khiva—the Liverpool, the Bristol of this slave trade—but I have not heard the same praises of General Kauffman for the rescue of several thousands of these slaves, whom he sent back to their own country—Persia. Professor Vambéry has truly said that mere preaching and teaching will never induce the Turkomans to give up this practice. They must be restrained by the strong hand. But who is to do it? Sir Douglas Forsyth and Professor Vambéry said the Turkomans had not attacked the Russians of late. Why not? Because they were afraid to do so; because they knew they would get from the Russians a great deal more than they gave. Why do they constantly attack the Persians and carry them off? Because the Persians are like sheep, quite incapable of defending themselves, and because they are subjects of the worst government on the earth,

except the Turkish. Professor Vambéry suggested that we should put life into the Persian Government—that our money and blood should be employed to guard the Persian. I beg to suggest to the Professor that two great Christian nations are charged with the pacification of Asia, Russia in the north and England in the south. It is a scandal to our common Christianity that the hostile feelings which prevail between these two great nations should be encouraged. It is the greatest possible injury to both. It wastes their strength, their money, their credit, their feelings, which ought to be applied to better purposes. The peaceful settlement of the world is impossible while this nonsensical Russophobia and Russian craze possess our minds; and to the intervening countries, which are ground between two millstones, it is simply destruction. See what is taking place in Afghanistan. We have cut off one-fourth of it under the name of a scientific frontier: now we propose to cut off a third more with Candahar. ("Question, question.") This *is* the question. This is no more a political argument than Professor Vambéry's lecture. I am speaking as to facts.

The CHAIRMAN: I am afraid you are verging on politics.

Sir CHARLES TREVELYAN: As a counterpoise to our Russophobian action on the side of Afghanistan, the Russians are prosecuting Anglophobian action on the side of Turkestan. The true remedy is that these two great nations should become friends, and should unite to promote Christian civilization throughout Asia.

General Sir HENRY HAVELOCK-ALLAN, Bart., V.C., K.C.S.I., C.B.: I should like to ask Professor Vambéry two questions. They arise directly out of the remarks which we have heard with so much pleasure from Sir Charles Trevelyan. One of the questions the Professor alluded to has much exercised the minds of statesmen of both parties in the country for many years. Professor Vambéry said some time ago that he thought it was possible to draw a line of demarcation which would reconcile the somewhat conflicting interests of England and Russia in Central Asia. I should like him to tell us whereabouts he considers that line might with advantage be drawn. Would he consider the north bank of the Oxus to represent the proper boundary? Then, another question arises out of that: Would Russia in his opinion be likely to respect that boundary? (Professor VAMBÉRY: I did not catch what you said.) The Professor has told us a great deal about the late unsuccessful attempt on the part of the Russians to subdue the Turkomans at Merv from the side of Geuk-tepe. That, of course, was an extremely difficult operation; but I should like to ask him whether he thinks there would be the same difficulty on the part of the Russians in subjugating the Turkomans if they were to start from the base of Samarkand *viâ* Bokhara, taking the Hadji-Kuyu road, and so eventually reaching Merv from the north-east or south-east. Does he not think that that would be a considerably easier operation and much more likely to be crowned with success?

Professor VAMBÉRY: In answering the questions which have been put to me in a very eloquent manner, I beg leave to sum up the rest of my observations, and I shall begin with the remarks made by Sir Douglas Forsyth, with regard to the Kirghiz and the Turkomans. I purposely abstained from entering on ethnographical details at this meeting, supposing that the question had been nearly exhausted, and that it was not worth while again to enter upon it. But now, speaking of the morals and habits of the Turkomans and the Kazaks, I would mention a few salient points in which the Turkomans differ from the Kazaks. The Turkoman is more wild, more rapacious, more soldier-like, more bent upon his independence. He is, so to say, the very pattern of Turanian nomads, as we find them described in ancient writings. Hospitality exists to such an extent that it is really scarcely imaginable to more civilized nations. When I entered a tent, the occupants of other tents in the neighbourhood got angry with the man whose guest I was, because they were not so fortunate as to offer me hospitality. I will give you an instance of the extraordinary idea of hospitality which these people have. I recollect one day I went out with two friends. They were beggars, as I was. Of course, you know, I travelled in the disguise of a dervish, in rags, in a very unbecoming suit, and little money with me. So we went to one of the tents. It was late in the evening. I entered, and made my salaam. . . . . The man received me with rather a gloomy and sulky look. I could not make out the reason. He bade us sit down. We sat down, and then he

looked very angry, till suddenly he said: "Will you lend me two or three kerans?"—a coin equivalent to a franc in France. We were amazed; we were his guests, and yet he asked money from us. Dervishes are not in the habit of lending money; they take money. However, I lent him the three francs, and he went out and bought rice and killed a sheep, and gave us an excellent supper; and whilst we were eating he sat opposite and enjoyed the sight. The next morning I left with my two companions. When we were a good way off, the Turkoman ran after us and cried: "Stop, stop." We stopped, and then he said: "Give me your money, "or I will take your life." I said: "You forget that we were your guests." "But "you are out of my tent now," he said, "you are not my guests now." I had six more kerans, and I had to give them to him. He gave me three back, and said: "Now "you have got the money you lent me." That will give you an idea of the characteristics of the people. After crossing the Atrek on our way to Khiva two camels died, and we had to get camels from the neighbouring nomads. We went there and asked them, and the owner offered us camels. I was only present as an eye-witness. The Turkoman in whose caravan I was took the camels, but he had no money to pay for them. He said to the seller: "I will give you the money when I come back "from Khiva." He asked me to sit down and write a kind of obligation that he would pay it. I wrote it with a small pencil, and handed it to the purchaser. He looked at it, and then gave it to the man from whom he had bought the camels. The man turned to me and said: "What am I to do with it? Give it to him: it may remind him that he has got to pay me." Only the chief men are very fanatical, the people generally are not so. You remember what Burnes has related. When they were asked why they sold Persians who were Mohammedans, they remarked: "The Book of God (the Koran) is certainly a more holy thing, and yet it is sold, and "why should not men be sold?" I will not detain you any longer with such trivial things, but will go on to answer the questions that have been put to me. Sir Frederic Goldsmid, who is a great authority on these matters, alluded to a pamphlet recently published by a Persian Minister. I have read that pamphlet. It is not a secret who is the writer: everybody knows it of course. The tendency of that pamphlet is, according to my humble view, that the Persians may get Herat. I am sorry to say that we must abstain from political discussions, but I would shortly remark that the claim of the Persians to Herat, and their pretence that they cannot control the Turkomans without having Herat, reminds me very much of a child who says: "I will take the bitter medicine if you will give me a great piece of sugar." The bitter medicine is the Turkomans, and the bit of sugar is Herat. As for the line of the Oxus, that is a question which deserves full attention on the part of statesmen. I am misunderstood. It is said that I am a politician. It is not politics; it is a grave and serious question of humanity which we are discussing—the civilization of the Mohammedan world in Asia. Some people fancy that because I am a Hungarian, I intend to imbroil Russia with England. Well, I have not the capacity to do so. Another person says that I am an Anglomaniac, and believe that whatever England does is good. No, that is not so. England does many things that are not good. But this is really a question of humanity. It is whether these Asiatics, who are children, ought to be led by the clean, steady, and firm hand of one nation, or by the unclean, unsteady, and weak hand of another? That is the question that has to be decided. Of course these questions will sooner or later, I am afraid, bring about a collision, and therefore I suggest that it would be undoubtedly the best thing to acknowledge the Oxus line of frontier. "The Oxus," however, is a very vague expression. I would refer my audience to the very able paper which Sir Henry Rawlinson published in the Geographical Society's Transactions on that point. The Oxus is divided into two great streams, one in the mountainous district ending at Kunduz, with two lateral branches, the Surkh-âb and the Panja; the other part of the Oxus flowing from Kunduz down the plain through Bokhara and Khiva to the Aral Sea. Well, the line which I refer to is that which runs through the plain. Iran is not only a poetical expression: it is an ethnical expression, a historial expression. Iran and Turan were always divided by that great, mighty stream. On the right bank of the Oxus is the real Turanian world, and on the left bank begins the Iranian world. Let Russia have all the Turanian region: I would not say a word about it, but I would say she must stop

there. Let her say: "This is enough. I have made a great enclosure here, and "here I remain and go no further." Of course, whether she will do that or not is a question of policy which I will not enter upon.

The CHAIRMAN: I will now beg to be allowed to make a few brief remarks. In the first place, then, as far as I can follow the drift of M. Vambéry's arguments and the general sense of the meeting, it seems that the opinion which is generally held is simply this: that it would be very desirable in the interest of peace and humanity to reclaim, if possible, the Turkoman tribes from their present wretched state of barbarism, leaving them in a sort of quasi independence, to cultivate friendly relations with all their neighbours, equally with Persians, Afghans, and Russians. That undoubtedly would be a most desirable consummation; the only question is as to its practicability. No one, I presume, would pretend to hold up the Turkomans as model tribesmen. They are notoriously the greatest brigands and ruffians in the East. But there is no proof that they are irreclaimable; on the contrary, Major Napier, who is our best authority as to their present disposition, has left on record an opinion that by careful and conciliatory treatment, supported of course by a powerful system of control, they might be reclaimed in time from their habits of brigandage and plunder. They have indeed been reclaimed to a great extent in some localities already, and it is quite possible they might be generally converted, by patient and judicious government, into an orderly and industrious agricultural peasantry. However, such a reform would no doubt require much time, great care, and the nicest management and circumspection. In fact, the practical difficulties are no doubt enormous, however desirable the consummation might be in theory. For instance, the first thing to be considered would be by whose agency is this conversion to take place—that is, by the agency of Russia, or of England, or of Persia? With regard to England, the *locale* is so remote as to be beyond the possible scope of our interference, and that must be the answer to the suggestion which Sir F. Goldsmid threw out, and which seemed to be favourably received by the meeting. Then if we proposed to employ the agency of Persia, it would seem from this last *brochure* on the subject which has come out under authority, and which has been alluded to by Sir F. Goldsmid, that the occupation of Herat would be a condition precedent to any such arrangement, and against that measure there are such powerful political objections that it hardly comes within the scope of practical statesmanship. It remains to consider whether the reform of the Turkomans might be accomplished by the agency of Russia. Well, now we have never certainly as yet seen Russia set to work seriously to convert Central Asian nomads into agricultural peasantry. Her attention has been rather turned to absorption and annexation and the extension of her dominions. Since she subdued the Cossacks she has made use of them almost exclusively for military purposes. Agricultural Cossacks at any rate are the exception, not the rule, and the natural inference therefore is that if she were to obtain the same supremacy and control over the Turkomans she would rather utilize their military capacity than convert them into mere tillers of the soil. Looking, then, at the question under these several aspects, I confess that I do not see any near prospect of a pacification and reform of the Turkomans. It seems to me far more probable that Russia will continue her military operations in the steppes with renewed and increased vigour, and that for two reasons: first, to retrieve the disaster under which her prestige at present suffers; and secondly, with a view to unite the Caspian Sea securely and permanently with the government of Turkestan, without which union, indeed, her possessions in Central Asia can have no real solidarity. Such being my views, I shall probably be asked what prospect there is of success in this scheme of conquest. I will not call it a mere ambitious scheme of conquest; it is rather the natural outcome of Russia's Central Asiatic policy. For it seems to be almost a law of nature that she should go on extending her frontier until there is what the French call a "*solidarité*" in her Eastern possessions. I take the liberty, then, of calling attention to the fact that it is only within these last few months that Russia appears to have realized the enormous magnitude and difficulty of the enterprise on which she has been so long engaged. It is only recently, as it seems to me, that she has taken the Turkoman question seriously in hand; the plans which are now being ventilated in Russia, as far as we can judge by the public prints, showing the impress of far more thought and care than characterized her

former movements. She no longer proposes in a mere haphazard way to launch an expedition into the steppes on the chance of frightening the Turkomans into submission, or possibly surprising and defeating them in the field. She is proceeding on a far more deliberate and carefully organized plan, which in the end, as it appears to me, must infallibly succeed. In the first place, instead of depending on carts and camels and accidental means of carriage obtained from so-called friendly tribes, she is deliberately preparing to lay down a line of rails from Krasnovodsk to Kizil-Arvat, so that she will be able to land her stores and war material on the very threshold of the enemy's country without any preliminary waste. This will take time no doubt, and moreover will be very expensive, but if judiciously and thoroughly carried out, the plan, I think, must succeed so far with regard to the Western or Akhal Turkomans. With regard to the Eastern or Merv Tekeh Turkomans a very pertinent question was asked by Sir Henry Havelock-Allan as to the possibility of throwing an expeditionary force across the Oxus from Bokhara, clearing the intervening desert of 150 miles and coming down direct upon Merv from the eastward. That, I do not hesitate to say, would be an operation of extreme difficulty and hazard in the face of an active and enterprising enemy. The plan has been often talked of, but probably never seriously contemplated. What Russia does propose, is to avoid the difficulties of the direct march across the desert by conducting an expeditionary force by a circuitous route where water and supplies are most abundant and where there are no physical difficulties whatever. She intends, it is said, to march by the line which has been recently travelled by Colonel Grodokoff through Sir-i-púl and Meymana, and which is parallel to the line travelled by M. Vambéry, so that she may strike the Murghab River at a point about half way between Merv and Herat, and descend the river upon Merv without meeting with any physical difficulty. From that direction, indeed, I venture to say that Merv is completely open to attack. I mention these two circumstances to show that the Turkoman question is entering on a new phase, and will probably in the future assume much larger and graver proportions than it has hitherto borne; becoming, in fact, the question of the day. It behoves us therefore, as I think, to study well the question in its present state, so that when the time comes, we may not be taken unawares, but may be prepared for the protection of our own legitimate interests. M. Vambéry's lecture has furnished much valuable light, as it seems to me, on the Turkoman question, and I hope, therefore, I may be permitted by the meeting to express their sense of the value of the obligation he has conferred on us, and to return him our best thanks, assuring him that on any future occasion of a visit to England we hope he will allow us to give him the same cordial welcome as we have on this occasion.

Monday Evening, April 19, 1880.

Colonel EDWARD H. CLIVE, Grenadier Guards, Member of Council, in the Chair.

ON "MANUAL" TRANSPORT.

By W. L. Geddes, Brevet Major 53rd Regiment.

A very few years ago anyone venturing to lecture on "Transport" might have counted on being favoured with a very small audience. Now, in this respect all is changed, for we see the congenial subjects of Strategy and Tactics giving place to the eminently prosaic but much more important point, "How masses of men *on the move* are to "be supplied with the numerous articles necessary for a modern army "in the field." How important the subject has become is shown by large audiences eagerly following the most technical details. It may, however, be safely affirmed that it is not in details that the remedy for transport difficulties will be found. Numerous wars have shown us our weak points, and though it is our custom at the end of a campaign to scatter not only transport material, but also, in a great measure, transport experience, still we have not been inapt pupils, and we may boast that we have little to learn regarding organization. What is really needed is a new departure *in toto*, for as yet, whilst the rest of the Army is the pink of mechanical perfection, transport arrangements appear to carry us back to the times of Alexander and Darius, or to the time of our own Edward III, who according to Froissart was on one occasion followed by a train of 6,000 wagons, stretching upwards of two leagues.

The object of this paper is more particularly to examine that part of the transport question dealing with the carriage of those different "necessaries," which must always be within reach of the soldier, viz., food, ammunition, and intrenching tools, more especially as regards the transport of ammunition and intrenching tools on the field of battle; but in order to make this portion of a vast subject clearly intelligible to those who have not a technical knowledge of the subject, a general view of transport arrangements must be taken. By condensing and divesting the subject of all technicalities it is hoped that this "going over" well known ground will not prove altogether uninteresting. No better idea of transport arrangements and difficulties can be found, than that given in the following extract from Home's "Précis of Modern Tactics." "If an attempt is made to "realize what was happening when the Crown Prince's army advanced, "it will be found that long columns of men and horses were spread

" along the different roads, and that the trains of each corps were " parked in rear, that is to say, the supplies of each corps were parked " in rear.

" When each column halted for the night at the places indicated in " the orders, the head of the column did not halt there with the tail " spread along the road it had marched on, but each corps drew its " tail up after it had more or less formed a line of battle. Thus the " roads were cleared, and it then became possible for the trains to " advance with food. But it is manifest that if the soldier having to " march 12 to 15 miles, and starting at 4 A.M. and probably not getting " settled into his bivouac until 3 or 4 o'clock in the afternoon, had to " wait for his food until the train arrived, he would be simply starved.

" Therefore it follows that if troops are to be fed in the field *they " must carry rations with them*, and the rations consumed during the " day must be replaced by the train during the night, so that the men " shall move off the following day with the same number of rations " as previously. Soldiers, if they are not to starve, must carry rations. " No one who has considered this subject will question the truth of " these words, and it is essentially requisite that this absolute necessity " be clearly understood by the men. A ration of fresh meat and " bread put into a canvas havresack and carried in the sun for ten hours " is not an inviting dinner, and the soldier often throws it away.

" The best food to carry is undoubtedly bacon, sausage, biscuit, " rice, &c.

" One of the Prussian Army Corps drawn up on parade ready to " march off, if inspected would have been found to have at least eight " days' rations with it. These would be divided as follows:—One " day's common ration for immediate consumption; three days' reserve " rations consisting of biscuit, coffee, bacon, rice and salt. The five " provision columns, viz., two for each infantry division and one for " corps artillery and cavalry, carrying four days more, the meat being " driven. The order to advance and leave the trains behind was " perfectly feasible; the Army could exist for four days without " seeing its train if necessary. But the moment the trains get the " order to advance they move up at night and fill up the rations " consumed by the troops, halting again when the troops advance.

" How are the trains themselves filled up? As far as possible " magazines told off previously in the same order as the corps pro- " vision columns, are formed. These magazines are the reserves, of " which the trains themselves are the expense magazines, and hired " transport carriages to the number of nearly 600 per corps are used to " haul up the provisions from the magazines to the trains and fill " them up as they filled the soldier. It is manifest that there must " be some limit to this operation. Assuming that the train can move " one and a half infantry marches, the limit would be six days when " the magazines must, if the Army is advancing, be moved to the front; " this would probably be done by pushing up by railway from the " great magazines of the country large supplies of food, &c., to fresh " advanced magazines, which would then fill up the train, and this " process would be repeated. This supposes nothing to be bought in

"the country or obtained by requisitions, but all brought from the "magazines."

From this description, terse, but with every word full of meaning, one point may be chosen for our purpose, viz., if soldiers are not to starve, they must carry rations.

This *personal* carriage of rations is most important to any army, but as yet with us this point has not received the attention it deserves.[1]

Not for want of warning, however, for more than one savage foe has shown us that "Manual Transport," or, in other words, the ability to dispense with the train for a certain time, means mobility. How often may be asked have golden opportunities of striking decisive blows been lost because a lumbering train has not been got together, or when got together has been simply able to crawl.[2]

It is evident we cannot afford to keep up the disciplined body of men, supplied with the necessary "plant," requisite for modern European warfare, as the conditions under which we usually fight are different from those of civilized nations. Transport with European armies means roads, supplemented by rivers, railways, and canals, a rich country, large populations, and abundant supplies; with us, in nine cases out of ten, transport means a barren and unknown country, with no roads. In Europe some estimate may be made of the difficulties to be encountered, but with us it is always more or less a leap in the dark. Nothing exemplifies this more than the examination of the different methods of carriage used in our past wars. Elephants, camels, horses, mules, bullocks, horse and mule carts, wagons, bullock carts, carriers, &c., have all served their turn. Of all these methods perhaps pack transport, with us, has the preference, simply because

[1] The knapsack reserve in Russia consists of three days' biscuits at 1·8 lbs. for each day, and a two days' reserve of salt, $\frac{1}{8}$ lb., consequently a weight of $5\frac{1}{2}$ lbs. In Germany the soldier also carries a three days' reserve, but this reserve consists not merely of bread or biscuits, but of several necessary requisites, viz., groats or rice, salt, coffee, and, if possible, of dripping and salt meat. The daily ration in war consists of (*a*) $1\frac{1}{2}$ lb. bread or 1 lb. biscuit, (*b*) $\frac{3}{4}$ fresh or salt meat or $\frac{1}{3}$ lb. dripping, (*c*) $\frac{1}{4}$ lb. rice or groats, (*d*) $\frac{5}{8}$ oz. salt and $\frac{7}{8}$ oz. roasted coffee. If no meat is issued, the ration of bread is increased to 2 lbs. Consequently the knapsack reserve of the German soldier (three days' portion) weighs 6·3 lbs. if the bread ration is in biscuit, if of baked bread the weight is increased to 7·8 lbs.; if no meat is issued the knapsack reserve weighs 8·55 lbs. This is called the "iron ration," because it is only to be expended by order of the Army Corps Commander. The "iron ration" must not be increased beyond a three days' supply.—(Colonel Hazenkampf, Russian Guard Corps.)

[2] At Umbeyla a rapid advance at first might have interfered with the rising of the hill tribes, but there was no proper transport. Hence the troops were delayed and the numbers of the enemy greatly augmented. In the Waikato campaign in New Zealand, after the skirmish at Kohera, the troops remained for fifteen weeks without making a forward movement, though the enemy's advanced posts were only three miles off. Again, in Ashantee our movements were slow. Had our small army been able to push on to the capital immediately after the arrival on the Prah of the envoy from Coomassie, there might have been no fighting at all, and the King, unable to assemble his men in time, would have no doubt agreed to the terms Sir G. Wolseley proposed before attacking his army at Amoaful. Here, again, want of sufficient transport delayed the troops and a rapid advance was impossible. The Zulu War is another example of lost opportunities directly traceable to transport difficulties.—("Studies in Transport," Major Furse.)

pack animals are not necessarily confined to roads. But of all transport this is acknowledged to be the most difficult to arrange; it has, besides, the great disadvantage of lengthening the column considerably on the march. Taking the mule as the representative of practical pack transport, two mules will carry from 320 to 400 lbs.; these require a man to look after them. Next come "carriers;" these have often proved their worth and even devotedness; they can follow the troops anywhere, the great objection being the small load each man can carry, rarely exceeding 40 lbs.; they occupy a large space on the march, and also require strong escorts. Camels can carry from 300 to 400 lbs., are easily fed and managed, but are difficult to transport by sea, and are delicate animals. Pack bullocks will carry about 160 lbs., and move at the rate of 2 miles an hour; they soon fall into bad condition if not supplied with abundance of food and water. Elephants are particularly useful, carrying 1,200 lbs. with a pace of $3\frac{1}{2}$ miles an hour, but it is needless to say that their numbers and sphere of usefulness must be limited. Wheel transport is of course the best, as it at least doubles the carrying power. Thus two mules will carry from 320 to 400 lbs., but the same two animals will draw in a wagon a load from 800 to 900 lbs.; but wagons mean roads, and heavy wagons good roads.

Now let us pause a moment and overhaul our deductions. First. We find that transport may be divided broadly into two parts, viz., the train which accompanies the army, and the transport that draws the supplies from the grand magazines to fill the trains and expense magazines.

Secondly. We may assume that though hired carts, animals, and drivers may do the rough work of filling expense magazines and the train, that the train should be a disciplined body with the very best plant.[1]

Thirdly. That the conditions under which we usually fight do not admit of our keeping up in sufficient numbers the disciplined train which European warfare demands.

Fourthly. That the soldier must carry rations; theoretically speaking the more he can carry the greater his mobility. Taking the question of the personal carriage of rations first, we find that science has in this matter come to our assistance, for by depriving the different articles of food of the water they contain a marvellous reduction of weight is arrived at. Admiral Selwyn clearly explained this in this theatre in June last, and I will take the liberty of using his own words. "We are all aware that a very large proportion of the weight "of every article of food arises from water. I am able to put before "you the fact that you can diminish the weight of all food necessary "to be carried by an army, its horses and men, down to one-sixth of "what is at present carried, and that with perfect facility. The "result of this will be that instead of 52 rations weighing 160 lbs.,

[1] Such undeniable military authorities as Napoleon, the Duke of Wellington, Sir Charles Napier, &c., have all been in favour of a disciplined military transport.—(Furse.)

"we shall bring them down to 27 lbs.,[1] and this will solve a very large "portion of the difficulty. I should like to correct a mistake made in "the House of Commons, where it was stated that the 'erbswurst,' "was simply peasoup. The 'erbswurst' is something more than "that; it is a carefully prepared chemical food in which every element "necessary to support human life is properly proportioned, and its "keeping qualities are absolute for any number of years."[2] So far as regards food, the soldier would have little to complain about even if forced to carry a week's supply; but unfortunately modern warfare has insisted on other loads being added to the already crushing weight on the soldier's back, viz., extra ammunition and intrenching tools. It is useless to shirk the question by supposing that "fire discipline" will compensate for want of ammunition, or that "toys," such as short-handled spades usually are, will do duty for serviceable intrenching tools. Since the introduction of the breech-loader, the rapidity of aimed fire has increased four or five fold, and we can hardly close our eyes to the fact that the adoption of a system of long-range firing is only a question of time. Captain Needham in his lecture—"Lessons "from the late War"—speaks of "the imperative necessity under "cotemporary conditions of warfare, of utilizing the power of firing "at long range conferred upon infantry by improvements in the "weapons they carry."

Rapidity of fire simply means great expenditure of ammunition, but when this rapidity is combined with a deliberate commencement at 3,000 paces, the expenditure will be simply enormous; but this is not all, excitement, panic, exhaustion, and the thousand and one unexpected incidents of a battle all go towards emptying the ammunition pouch. Statistics on the expenditure of ammunition must necessarily be deceptive *unless every unit* (whether this unit be a battalion, company, or section) be accounted for—not only as to the number of rounds it has fired in the action, but the time it was firing, the number of separate attacks made or repelled, and the average distance from the enemy. It is evident that by lumping the whole expenditure of ammunition in an action, and dividing by the number of men present, an absurdly low average would probably be obtained. Such statistics can have but little practical value except to some official dealing with the question of the general supply of ammunition. To the general public such figures are often absolutely mischievous. We are told that in the engagement on the Bistritz, the 1st Army Corps fired 12 rounds per man, *but in one battalion*, and here is the point, the expenditure was six times as great, and in some companies even greater. The only lesson to be learnt from such an example, if lesson it can be called, is that every company should be supplied with ammunition in sufficient quantity to bear the whole brunt of a battle. The Turks were most prodigal in their fire; they were also successful in

[1] All Officers and other soldiers when in the field draw the following rations daily:—$1\frac{1}{2}$ lb. of bread or 1 lb. biscuit, fresh or salt meat 1 lb., coffee $\frac{1}{3}$ oz., tea $\frac{1}{6}$ oz., sugar 2 oz., salt $\frac{1}{2}$ oz., pepper $\frac{1}{36}$ oz. When troops are marching or doing hard work, $\frac{1}{4}$ lb. more should be added to the meat ration.—(Sir G. Wolseley.)

[2] See Journal, No, 102, page 815.—Ed.

supplying themselves with ammunition, and they produced some astonishing results. Instances occurred where battalions fired per man as much as 400 rounds in 48 hours, and even in skirmishes of an hour's duration, 50 or 60 cases often lay by the dead. The Turks carried little but ammunition and food, so each man managed easily to take 100 to 120 rounds about him, and each battalion of 600 men had 30 pack horses, carrying 60,000 rounds. This was the secret of their success. The pack horses were led in action by men of each battalion in rear of the shooting line with wonderfully little loss, and could go anywhere. Major Fraser in his " Gold Medal Essay " says, " That the Russians in " the last campaign had cut down their regimental transport to twelve " ammunition carts for three battalions, and on *several occasions* they " ran short in action—notably in Krudener's attack on Plevna, in " which a portion of the ammunition column had stuck at Bulgareni, " so that in *four hours* the men had fired all they had. Nor was this an " isolated case, for Zeddeler tells us that generally the trains had great " difficulty in getting within reach of the troops, and he speaks of the " absolute impossibility of supplying ammunition without pack horses."

Again, the Prussian Guard advancing to attack St. Privat lost some 6,000 men in ten minutes. The lesson here is not altogether tactical, for it shows the amount of ammunition that must have been expended in that short space of ten minutes to effect such results. The difficulty in getting at the ammunition when the pouches were empty, might have been, and probably was, the cause of the Isandula disaster. Let us imagine a company detached from the main body, surrounded by a determined fanatical enemy in overwhelming numbers, bringing up fresh men as each attack was beaten back—three shots per minute would empty the men's pouches of the regulation allowance of ammunition in less than twenty-five minutes. Comment is needless. When a large army takes the field against a comparatively equal foe, military science demands that there should be supports and reserves to the fighting line, and by relieving or reinforcing the fighting line by fresh troops any deficiency in ammunition may be corrected. But in our wars with semi-barbarous people, we are often obliged, on account of our great numerical inferiority, to place all our men in fighting line, which has to take care of itself without any hope of assistance. These considerations, and the possible adoption of "repeating arms," as advocated by many, all point one way, viz., that there must be no dearth of ammunition. " Fire discipline," which is presumably the modern phrase for musketry instruction, simply means the feeling of security men have when they are conscious of being well armed and know how to use their weapons, but this feeling of security must necessarily be lost if any doubts arise as to the sufficiency of the ammunition. How much ammunition our soldiers should always have at hand is a question of the utmost importance, but double the present regulated amount would hardly be excessive.[1]

[1] General Zeddeler points out the absolute necessity of largely increasing the number of ball cartridges available in the Russian Army during action, and which, it may be remarked, is much the same as in our own. He strongly insists on the advisability of giving to the men from the outset a greater number of rounds, sug-

The necessity for having a sufficient number of intrenching tools always present with the men is now generally admitted, but this is no new idea. Napoleon said: "There are five things from which the "soldier must never be separated, viz., his gun, his ammunition, his "knapsack, his rations for four days, and an intrenching tool." We often read in military history of villages being taken and retaken several times in the day; these are the moments when success may be secured by being provided with intrenching tools. Captain May, in the "Tactical Retrospect," says: "The engineer, in virtue of the "character which is particular to his branch of the service, may hold "an equilibrium in military operations. He may render the success "gained by an impetuous attack secure by quickly throwing up field-"works behind the attacking force, and in the same manner stop a "retreat by hastily constructed intrenchments." But hastily constructed intrenchments do not require the skilled labour of the engineer; such works could be as well done by the supports and reserves of the fighting line, or even by a portion of the fighting line itself, provided always that the troops had had instruction in making simple fortifications. Home gives an instance where there was no tactical connection between the works and the troops. At Konigratz "the Austrians appear to have thrown up a good many intrenchments "by the engineers, but the corps and division leaders knew nothing of "these works, or of the exact positions they were to hold. They "extended far beyond the position intended, and the commanding "engineer, riding round some hours after the battle had begun, found "there were no troops near the works at all."

Such a mistake could not have happened had it been the business of the troops themselves, or a portion of them, to help to construct the works they had to defend. Again, quoting May and Home: "Not "only were the pioneer duties of the Prussian Army admirably per-"formed, but the *true spirit* of the use of field engineering was in "many cases seized." One remarkable instance was at Mars-la-Tour. Early in the day the Prussians gained possession of Vionville. The instant the infantry got in, two companies of engineers, supplied with six wagons of tools, were pushed on. They were charged by a regiment of French hussars, and lost some of their wagons and a section of one of the companies, but the remainder got into the village, and so strengthened it that all attempts made to retake it, failed. Here not only have we an example of the use of intrenching tools near at hand, but also a pretty plain lesson that they should actually accompany the attack. What might have been the result had the hussars succeeded in capturing all the wagons, instead of some? Speaking of the same battle, Home says: "The want of tools was sorely felt all along the "French line, from the fact of the tools not being in the front, but in

gesting that each man might carry 105 rounds, viz., 60 in his pouch and an additional 45 in his havresack. But at the same time, recognizing that there is a limit to the burden which it would be wise to impose upon a soldier, recommends a corresponding diminution of his general equipment. He advocates that the first or immediate reserve of small arm ammunition, viz., 25 rounds per man, be carried on pack animals, the second or larger reserve in carts or wagons.

"the rear. No one who examines the history of this battle but must "feel that had fortifications been used to support the troops with "judgment, a different result might have followed."

Now, when theory and practice both agree as to the value of intrenching tools up at the front, how, it may be asked, is it that they are seldom to be found when wanted on an emergency? The reply is simple and conclusive—the question how tools are to be carried has never yet been satisfactorily answered. In Prussia it appears that certain battalions carry short-handled tools, but these necessitate the digger working on his knees. Long-handled tools, on the other hand, are apt to hamper the soldier and prevent the free use of his weapons. We may, therefore, assume that if a soldier has to carry an intrenching tool as part of his personal equipment, it must necessarily be a short-handled one.

The different methods of carrying tools are (Brialmont):—

In the United States, the tools of each battalion are carried in turn by the men of two companies at a time, thus making the carriage of the tools an irksome and disagreeable duty. It is not very difficult to imagine that under these conditions many would be deficient after a long march. In France, long-handled pioneer tools, weighing about 4 lbs., are carried in rear of regiments. Rogniat wished to give pioneer tools as a *mark of distinction* to two picked companies in each battalion.

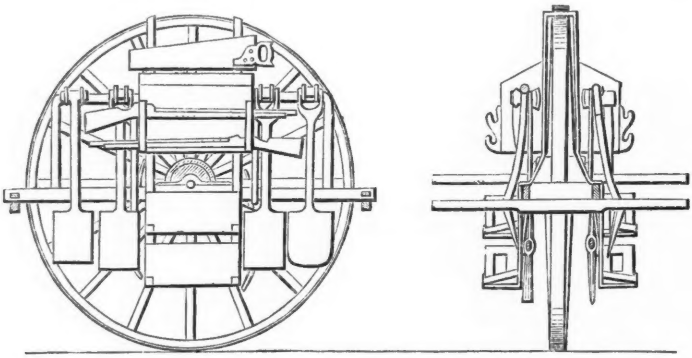
Brialmont himself supposes that either all the soldiery should be furnished with tools weighing about 2 lbs., or else the men in the front rank only should be provided with them; but, on the other hand, Captain Kouropatkine, of the Russian Staff, whose experiences of the late war must give great weight to his opinions, has expressed a very decided opinion against giving tools to the men themselves to carry. The first thing he notes which a man throws away when he becomes distressed, or when he wishes to go forward more rapidly, is his intrenching tool, and therefore, if these are given to the men, they are very likely not to be forthcoming when they are wanted.

There is one other weight to be considered, viz., water. The Turks had a pack horse for water for each company, which enabled them to fortify and hold positions which they must otherwise have abandoned. Thus the Russians, for want of water, had to abandon the great Yagni hill after they had captured it. At Zevin, too, Russians left captured trenches to get water, and Skobelow's forethought in detailing "water parties" for the working and attacking columns at Loftcha and Plevna is remarkable.[1]

Modern warfare demands that the soldier should have ammunition in plenty, food, intrenching tools, and water constantly with him, but human nature revolts against being thus heavily weighted, so it is not surprising to hear that the campaign of 1877–78 is remarkable for the disuse of the knapsack. The men carried three to six days' biscuit, and a bag or bundle of clothes, but the distances to be traversed in attacking works is now so long and the effort so great that the troops constantly throw away everything, and then there is a risk that, after

[1] Major Fraser, "Gold Medal Essay."

a successful assault, they are unable to exist on the captured position. How are these antagonistic necessities to be reconciled? On the one hand, if the soldier does not carry the several articles mentioned, he is but half armed; on the other, if he does carry them, he will be either exhausted or be tempted to get rid of what he considers superfluous weight as soon as the great fatigue of an advance under fire begins to tell upon him. The conclusion is obvious. Spare ammunition, water, and tools must be carried for the soldier by men who will not hesitate to take their charge into the fighting line; in other words, trusty comrades, specially detailed for this honourable duty, must be ever ready to supply the wants of their fighting brethren, either in ammunition, food, or water.



Side elevation. End elevation.

Scale ⅓ of an inch = 1 foot.

I have now the honour to submit to you a design for an "ammuni-"tion and intrenching tool carrier," which I confidently believe will compete favourably with the mule as a military carrier. As you will perceive from the diagram, the principle is to have a single wheel of large dimensions, surrounded by a yoke, on to which the several articles are attached. A slight examination of the "model" will show the extreme simplicity of the machine, and will save me a somewhat difficult explanation. The wheel made for me for experimental purposes was defective in some minor details, but I satisfied myself that, with a load of 400 to 500 lbs., it had a very easy draught on a good road, three men being necessary to work it. These three men are amply sufficient on any road which may be deemed fairly passable, but when required to leave the road to follow a regiment in any tactical manœuvres, an extra man must be tackled on. Four men will be sufficient for any ordinary rough cross-country work. There is, however, room for six men to tackle on, and on one occasion on the "Fox Hills," I had to use this number; but this was an exceptional case. The equipment of the carrier, subject to modifications, is 4 picks, 4 spades, 4 shovels, 2 saws, 2 axes (felling), 2 hatchets,

4 regulation boxes ammunition. I propose that one of these " carriers " should be a part of the equipment of every *half* company. Thus a company (say, 100 strong) would go into action with serviceable intrenching tools for 24 men, and a reserve of some 50 rounds per man.

It has been objected that the use of such vehicles would necessitate the withdrawal of eight men per company. My answer to this is that this " withdrawal " is more nominal than real. The men are there; their arms are handy, and at any moment they can take their places in the line, leaving the " carrier " to shift for itself; *it cannot run away*. Some modification of the tactical arrangements of a company would be necessary, so as to enable the " carriers " to be with the supports. But it is as giving mobility to the company, the natural unit in our Army, that the " carrier " would be found so useful; but in this case two extra carriers would have to be attached to each company, to carry food, water, &c. A company thus equipped would be complete as a moveable machine, as well as a fighting one. At Isandula, we hear of a company being detached and never being heard of again. We can hardly doubt that, with intrenching tools ready at hand, and plenty of ammunition, such utter obliteration would at least have been prevented. Often have such detachments to be made by our small Army. With " carriers " properly found with food, ammunition, and intrenching tools, a company would be ready in five minutes to move anywhere, and exist for a lengthened period. It is not difficult to picture what advantages might be gained and what tactical and strategical points seized by an army whose units possessed this mobility. As for the company itself, having been in possession of the tools as a part of their equipment, and thoroughly taught their use, being separated from the main body would be of little consequence; in a few minutes an intrenchment would be made, a few hours longer this would be converted into a formidable work; if the stay was to be lengthened, arrangements would be made for constructing huts or shelter. The soldier of the present day is quite intelligent enough to do all this, if he is only taught how to do it. But to return from conjecture to fact. We have the opinion of an experienced Russian General that it is impossible to supply troops in the field with ammunition without pack horses. This will give the " carrier " a standard for comparison; two mules will carry from 320 to 400 lbs.; one " carrier " will carry from 400 to 500 lbs. The mule or horse requires food, may be restive or sick, and is liable to be killed. The " carrier " has none of these disadvantages. The mule requires an attendant, and, in the field, probably two; the " carrier " requires four, but whilst the mule attendant or attendants must necessarily be non-combatants, those of the " carrier " can always take their place in the fighting line. Now let us look at the " carrier " in another light, viz., as a means of ordinary transport. The light frame-work for the tools would be replaced by a leather bag or netting, capable of containing various stores. Human carriers, probably coolies, would be used for this purpose. Here, again, we have a standard for comparison. The load for a human carrier is from 40 to 50 lbs.; generally the lesser weight.

The mechanical "carrier" will increase the human carrier's transport-power from 50 lbs. to 100 lbs. *at least.* With ordinary vehicles of two or more wheels a single "wheel" can only compete in the matter of mobility, but this is all-important for military work. The "carrier," for instance, could move along a slope which would infalliby upset any ordinary carriage.

A very serious item in the manual transport question is the carriage of the soldiers' clothing. As "valise equipment" is at the present moment under the consideration of the authorities, it may appear out of place to offer any remarks as to how the soldier should carry his kit, but I submit that knapsacks, valises, &c., are "peace baggage." Something infinitely more simple must be carried in war. The kit must be cut down to absolute necessities—say a change of clothes all round, with perhaps the addition of a Guernsey or other warm substitute for the tunic or serge. Now we have been told that the campaign of 1877–78 was remarkable for the disuse of the knapsack, and that the men carried a bag or bundle of clothes; but how this bag or bundle was carried has not been clearly explained. However, it is not difficult to imagine such a bag or wallet. A strip of waterproof, say, five and a half feet long and a foot and a quarter broad, is doubled along its length, closed at the ends and along the side, with the exception of eighteen inches left open in the middle for purposes of packing, in fact nothing more than an enlarged old-fashioned purse. It is surprising how much can be crammed into this apparently small receptacle, and, comparatively speaking, how easily the things are carried. This is due to the weight being supported on the top of the shoulder. This wallet is easily transferred from shoulder to shoulder, thus enabling the man to ease his shoulder when tired or hot. I would also ask, Have the improvements in waterproofing received the attention they deserve? Waterproofs are warm, comparatively light, and are absolutely necessary for those who have to sleep on the ground, and, above all, *easily packed.* The prejudice that waterproofs are not healthy may be right or wrong, but what can be worse than a sodden felted garment with no chance of drying it? The infantry soldier's great coat is heavy, not easily packed, and when wet, dried with difficulty. Is it hard to conceive that a waterproof cape or coat, supplemented by a Guernsey for heat, would not be more serviceable in the field than the present time-honoured garment?

I will now ask permission to be allowed to wander from the subject of manual transport for a few minutes to say a few words on military railways. In bringing up supplies, railways cannot be surpassed, for not only can large loads be carried, but supplies are not consumed *en route*, as in all other modes of transport. Colonel Hazenkampf, speaking of the Abyssinian campaign, brings this consumption *en route* vividly before us, and concludes thus: "The distance from Coomailo "to Magdala was in all 370 miles; had the English had to penetrate "more deeply into the interior, a time would eventually have arrived "when no transport would have ensured their supply, as everything "would have been expended on the road by the bearers, the pack "animals, and their drivers."

To us belongs the honour of being first in the field in the endeavour to construct a railway during a campaign for purely military purposes, but neither our Crimean experiences nor those in Abyssinia in railway construction, can be considered satisfactory. As for the line destined for Ashantee, it was never even landed. It may, however, be somewhat consoling to our *amour propre* as a railway-building nation to know that the one purely military railway constructed by the Germans at Metz was a decided failure. Is it presumptuous in an "outsider" to suggest that heavy earthworks require time to consolidate as well as time to construct, which at once puts such constructions out of the sphere of military usefulness? A railway without earthworks or cuttings, easily and quickly constructed, easily repaired when destroyed, and proof against tropical rains, would be an untold boon to our Army.

Gentlemen,—Being purely a regimental Officer, it was with much diffidence I offered to lecture on so technical a subject as "transport," more especially as my audience would probably contain many Officers with large practical experiences, whilst I can claim but a limited theoretical knowledge. My object has been simply to lay before you the train of reasoning which induced me to design a mechanical substitute for a pack animal, but in doing so I trust I may have opened up a much larger question, which may be thus epitomized: "Have we ever "rightly tried by *mechanical means* to reduce the number of 'mouths,' "human and animal, which follow and hamper our armies?"

Major Truell, 53rd Regiment: I have not had the opportunity of reading Major Geddes's interesting paper this evening; but having received a note in reference to it, I thought I would attend. He has told us quite truly of the great necessity of getting ammunition into the first line. I have studied the subject, but find it full of difficulties. From Colonel Baker's account of the war in Bulgaria it appears that the plan of each regiment having its own mule transport for spare ammunition worked well; but the system entails a man to look after the mule and also food for the animal to be carried, which is apparently what Major Geddes wants, if possible, to avoid. I think his machine ought to be tested at the Aldershot field days, but I fancy mule transport most practicable.

The Chairman: The subject on which Major Geddes has read his paper is a most interesting one. The carrier appears to have many valuable qualities, and to be calculated to render efficient service to an army operating in a district where roads are scarce or of bad quality. Up to the present time, the only means of transport that have received consideration have been baggage animals, two-wheeled carts, and wagons; and I believe this is the first occasion when manual power has been suggested as a means of supplying an army with its necessities. If any gentleman would like to offer some remarks, I think it would be for our advantage as well as for that of the Institution, and for the good of the Service.

Major Truell: I should like to ask Major Geddes how he means to work his wheel along a footpath with a very severe slope, such as a mule could travel on with a fair load?

Major Geddes: In the first place the wheel carrier has to be made of large dimensions. It is bound to be 6 feet, in order to clear the ground with the two ammunition boxes. If you were to put two wheels, the machine would be heavy, and you would not be able to carry more. It could not go through a less space than 3 feet, but no inclination that I know of will affect its stability.

Major Truell: I have been informed that in Abyssinia they had to unpack mules because they got to such narrow places that they could not pass. Can you get the axle suited to pass such places?

Major GEDDES: It could be taken out like the axle of any other wheel.

Major TRUELL: You could take it out and get the carrier through?

Major GEDDES: Yes.

General Sir HENRY W. NORMAN, K.C.B.: I am quite sure that all present have been interested in, and have received instruction from, Major Geddes's paper. His invention is, to me, quite a novelty. The only occasion I can call to mind on which any sort of hand cart has been used in war was in the China War of 1860, in which, I believe, a considerable number of wheelbarrows of the country were used. Perhaps some Officer here present may have seen this wheelbarrow transport. I have heard that the Chinese coolies who worked the barrows showed great resolution and endurance. No doubt Major Geddes's invention would be useful in some cases, though there must be circumstances in which it would be impossible to use it. I should think that in a mountainous country, many hills would be too steep to allow of its use without the aid of an excessive number of men, and it would be difficult to move it along rough narrow mountain paths, while we know that mules and even elephants can follow troops over very difficult ground. Major Geddes's invention, of course, is intended to bring up to the front line a supply of ammunition and food, and will in no way meet the great difficulty respecting transport for an army in the field so as to maintain the troops. As has been justly said in the lecture, in European warfare there are usually railroads, large towns, a considerable population everywhere, and plenty of food. In the countries in which our troops have of late years served in the field, there are usually few inhabitants and very little in the way of provisions. Everything has to be carried for the troops, and if anyone can devise means for the ready transport with an army of say a fortnight's full supplies, so as to make the troops independent if their communications with the base are temporarily cut off, as sometimes occurs in India, a very important problem will have been solved. Recently there has been something written of an army crossing a desert and carrying, besides its provisions, water for several days. Few people, I suspect, have calculated the enormous amount of water that would be used daily by an army and its transport cattle. A march of any duration is, I think, quite impracticable, unless water is to be found on the road. Something in the nature of what Major Geddes has described would, no doubt, be very useful for an army in many parts of the world, and I am sure we are all obliged to him for his paper. I would wish, before sitting down, to say a word about concentrated foods, which have been alluded to in the paper. I have read lately a good deal about the use of this sort of food, and I see a medical friend of mine present who could give valuable information respecting it; but so far as I have been able to ascertain, this food is rather valuable to supplement the ordinary ration, or to make up for a deficiency in it, or for the sick, than as an entire substitute for the ordinary ration. Indeed, it seems doubtful whether troops could possibly march for more than a day or two if provided only with concentrated food.

Major-General BURROUGHS, C.B.: With regard to the remarks of the previous speaker, it appears to me that Major Geddes's invention is not intended by him to be a substitute for the ordinary transport train, but as a very valuable supplement to it. No machine yet invented can do everything. No animal can go everywhere. Nor does the inventor of this machine profess to be able to do everything with it. As he has so lucidly explained, the principal object of the carrier is to supply the fighting line from its supports and reserves with ammunition and intrenching tools; to supply, in fact, a want, how best to supply which, is now puzzling the heads of soldiers of all nations. As Major Geddes has told us, the carrier does not eat, it cannot run away when its services are most required, and the men with it are always available for the fighting line. It seems to me a most simple and useful invention, and the only wonder is that is has never been thought of before. It strikes me it could be utilized in very many ways. For instance, those who have served in India know that bodies of troops in that country are always followed by water-carriers, either carrying skins of water on their own backs or driving a bullock with water-skins suspended across its back; and all will remember, when parched with thirst, how sickening, instead of refreshing, a draught of such tepid water was. The carrier could be laden with water-skins, and these could be kept cool by any of the many appliances for keeping water cool so well known in hot countries, and

which it is not possible to carry out when it is conveyed on the back of a broiling bheestie (or water-carrier) or of a sweltering ox. The carrier, trundled by coolies or the native labourers of the theatre of war, could be laden with the field kits and day's rations of the fighting men, and could follow them almost anywhere troops are likely to go. For very special cases, special means must of course be adopted, If, as has been stated in the public papers, the troops at Isandula fired away all the ammunition they carried, if each company had been followed by two carriers laden with spare ammunition, as suggested by Major Geddes, the disaster could hardly have occurred; for the same papers say, that the Zulus were just wavering and about to fly, when they perceived that our soldiers' ammunition was exhausted; this emboldened them to press on and overwhelm their adversaries by sheer force of overpowering numbers. In fact, it strikes me that the carrier could be put to very many uses. Its construction is most simple and inexpensive; it does not eat, it can go almost anywhere, and it appears to me to supply a much needed want, and to be a very valuable supplement to existing means of transport.

The CHAIRMAN: In the first place, I think it is one of the most valuable privileges of this Institution, and one it is most jealous of, that it enables the members to discuss new inventions which cannot be discussed in any other place in London. There is no other place, as far as I know, where any Officer who has an invention beneficial to the Service will obtain such a hearing as he will get in this theatre.

I will now ask your leave to make a few remarks upon the invention under consideration, expressing first our thanks to Major Geddes for his very lucid paper. The general principles of this carrier seem to me to be very sound. Never having seen it in operation, I know no more of it than any other member in this theatre, and of course it is not intended to replace pack animals or wheeled carriages, but only to supplement the means of transport that we now have in the Service. I understand that these carriers are to be kept as a part of the regiment equipment, to be brought into use when regiments take the field, and to be applied to the carriage of food, ammunition, intrenching tools, or other stores in places which cannot be conveniently reached by our ordinary means of transport. The necessaries for troops in the field may be limited to food, water, intrenching tools, and ammunition, but the last may be said to be the most important. The Turks at Plevna obtained great credit for the organization by which they were able to supply cartridges to the troops in the advanced positions, by means of pack animals; and this has led many persons to the opinion that the distribution of ammunition can be better made in this way than by our system of two-wheeled carts. But it must be recollected that a stationary camp like Plevna, with its communications always open, affords facilities for such a service, which in all probability will never recur. Major Fraser, R.E., has shown in his essay how the Turks contrived to keep up an almost continuous fire by day and night; and when the camp was taken, boxes containing 100 or 200 cartridges or cases were found by the side of the rifles, the whole of which had been brought into camp by convoys of pack animals, and distributed by the same means. But this will not necessarily prove that such means are the best, though they were successful until the time when the investment of the camp was completed, and the supplies stopped. Similarly, the best mode of supplying intrenching tools has yet to be elaborated. Major Geddes has stated that Captain Kouropatkine, a Russian military critic of eminence, has expressed a decided opinion against supplying the men with intrenching tools, which, the Captain states, are the very first articles that the soldiers throw away when advancing, and when required they are not forthcoming. I did not know that Captain Kouropatkine had expressed such an opinion. I do know that the Russian soldiers had no intrenching tools when they were required, but I did not know that they formed part of their soldiers' equipment. When the Russian Army first took the field, I believe, no tools accompanied the troops. Later, when the want of them was felt at the attack on Plevna, the tools were brought up in wagons, and distributed in the field to the troops. In theory, they should have been collected after the intrenchment was completed, replaced in the wagons, which again would convey them to a more advanced position. It is needless to say that this was never done, and when the troops advanced again the tools were deficient, having been left in rear of the previous

entrenchment. My own opinion is that every soldier should carry his own spade or pick, and when he came to know its value, he would take care to keep it by him. I must apologise for having digressed from the subject of Major Geddes's carrier, but I have done so because the system of his invention is to carry certain articles necessary to troops for the men, and to distribute them in the field; whereas I hold that all necessaries should be carried by the men themselves, and that the rest of the kit should be carried for them. I believe this is the German system. But, nevertheless, the description of articles carried on the carrier will not affect the value of Major Geddes's invention, which is to supplement horse and wheel transport by these carriers moved by manual power; and I hold that, subject to their having stability, and a stability irrespective of the load upon them, they would be most useful adjuncts to a battalion in the field. (To Major GEDDES: Has it been tried at Aldershot? Major GEDDES: I tried it all over the Fox Hills myself, but not with the battalion.) I trust that the military authorities may be induced to consent to two or three of these instruments being made for purposes of experiment at Aldershot, where it would appear to be easy in a short course of trials to ascertain whether they would not be an advantageous addition to the equipment of an infantry battalion. I have, gentlemen, to request leave to be your spokesman in conveying to Major Geddes your thanks for his paper.